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THE PRECANCEROUS CHANGES IN THE RECTUM AND COLON

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ONE of the greatest difficulties in studying the etiology of cancer from a clinical standpoint is that the disease is seldom seen except in the late stages when the growth has already reached a considerable size; it is not until then that symptoms are produced. Thus but little is known of the early stages in the development of malignancy and the changes in the normal epithelium which ultimately result in the transition from the normal to the malignant tissue are still but little understood. This is true of all cancers, but our study of precancerous conditions has been confined mainly to cancer of the large gut.

In the vast majority of cases of rectal cancer, there is nothing in the patient's history pointing to any previous condition which might be a forerunner of the tumor. It has been surmised by some writers that long existant piles either internal or external may give rise to cancer if neglected, but we have never come across any cases which would seem to lend credence to such a view. It might well be supposed that chronic pruritus ani might lead to the development of epithelioma of the anal skin, but we rarely have a case in which this has occurred, although epithelioma of the vulva is not an uncommon result of pruritus vulvæ.

Chronic fistula does occasionally appear to act as an exciting cause of cancer and we have records of two cases in which a carcinoma arose at the inner opening of a chronic fistula. On the other hand we have seen fistulæ which have existed for as long as 50 years without the development of cancer. Chronic constipation has been said to be a predisposing cause, but there is no satisfactory evidence in support of this view. It must be admitted that apart from adenoma we know of no condition in the rectum which predisposes to cancer with any frequency.

It has been increasingly evident in recent years that the etiology of malignancy cannot be elucidated by the histological study of fully developed tumors, and that it is necessary to go further back and study the changes which occur in the epithelial cells before this stage of malignancy is reached. This histological study of the changes which precede the development of cancer in the human subject is handicapped by the difficulty of obtaining suitable material, nevertheless notable progress has been made in such investigations. Thus, for many organs of the body, chronic hyperplastic changes, such as those Sir Lenthal Cheatle has described in the mamma, have been recorded as commonly preceding cancer. In this paper, we shall

Fig. 1. Illustrating the microscopic appearance of a section showing local hyperplasia of the mucous membrane of the rectum. The epithelial proliferation is not yet visible to the naked eye.

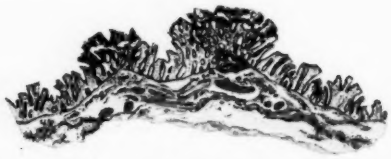

Fig. 2. Local hyperplasia leading to adenoma. This degree of epithelial proliferation reveals itself as minute, rounded elevations on the surface of the bowel, just visible to the naked eye.

provide pathological and clinical evidence that similar epithelial proliferations frequently precede cancer of the rectum.

It is now a well established fact that adenomata of the mucous membrane of the large intestine are peculiarly liable to undergo malignant change. The following case will illustrate this process.

CASE 1. A gentleman, 58 years of age, was brought by his doctor to see one of us (P. L. M.) on account of a tumor in the rectum. The tumor was about the size of a two-shilling piece, sessile and soft, and was situated on the anterior wall of the rectum about 3 inches above the anus. A careful microscopical examination of the tumor after its local removal and after several sections had been cut from different parts of the tumor showed the structures of a simple adenoma. There were no signs of malignant change. The patient returned home after being instructed to have periodic examinations made. He neglected to follow this advice and was not seen again for 15 months. He then had a malignant tumor in the situation of the previous adenoma. It seemed certain that the adenoma had recurred and had subsequently undergone rapid malignant change.

The best clinical examples of the simple adenoma which undergoes malignant change and develops into typical carcinoma are seen in those rather rare cases of multiple adenomata, or adenomatosis. This curious disease has a familial tendency, in fact, it is a true Mendelian dominant; furthermore, malignant change in one or more of the tumors always occurs. Such cases afford us an opportunity of studying the precancerous condition and have been of the greatest value in this connection.

In 1923, one of us (P. L. M.) stated that simple adenoma, whether single or multiple, should be considered as a definitely precancerous condition and treated as such. Since then much evidence has accumulated to confirm this view. The histological examination of large simple adenomata, by cutting several sections from different parts, has not infrequently demonstrated commencing malignant change in one part of a tumor which was otherwise benign in character. We need not dwell longer on this point since the frequency with which cancer begins in adenomata is now more generally admitted and in a recent paper one of us has reviewed, from the pathological aspect, the relationship between simple and malignant tumors of the large intestine. In the bibliography, we append references to the articles which have appeared in the last 2 years in each of which the close relationship of adenoma to carcinoma is emphasized.

RELATION OF EPITHELIAL HYPERPLASIA TO ADENOMA

If the piece of bowel which is removed by the operation of excision for cancer of the rectum is pinned out immediately to prevent distortion and after fixation in 10 per cent formol saline, examined with a low power microscope or powerful lens, the mucous membrane will often show irregularities in contour not visible to the naked eye. We have noticed these irregularities particularly in two pathological conditions—multiple adenomatosis and early cancer of the rectum. On section and microscopic examination of such an area of the bowel, the irregularity is seen to be due to a localized epithelial hyperplasia. The hyperplasia may be so slight as to be quite invisible to the naked eye and only detectable on microscopic examination (Fig. 1), or it may be large enough to be noticed as a tiny, smooth, rounded elevation (Fig. 2). This irregularly distributed hyperplasia represents the first stage of tumor formation,

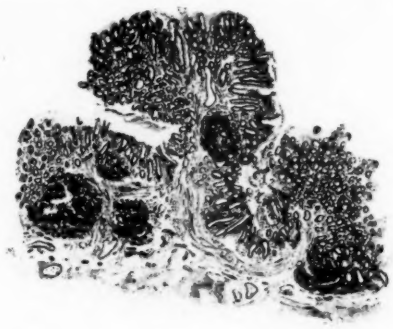

Fig. 3. Adenoma of the rectum. One of many tumors found scattered over the mucous membrane of the rectum in a case of early cancer.

Fig. 4. Malignant disease commencing in adenoma of the rectal mucous membrane. The malignant change is limited to the top and one side of this tumor but cancer cells are to be seen also invading the submucosa (indicated by the arrows).

and we wish to draw attention particularly to three points with regard to it: (1) that it is found most frequently in association with multiple adenomatosis and cancer of the rectum; (2) that it is more likely to be found in the neighborhood of a small malignant tumor than a large malignant ulcer; and (3) that it affects an extensive area of the bowel, several inches above and below the cancer.

No sharp line of distinction can be drawn between this hyperplasia and adenoma: in practice we reserve the term adenoma for a glandular tumor visible to the naked eye, and class as hyperplasia similar changes on a smaller scale only visible on magnification. Histological examination of adenomata (Fig. 3) proves that they represent only a more advanced stage of hyperplasia, necessitating an architectural modification in the normal relationship of epithelium to connective tissue in order that the greater number of secreting cells can be supported and adequately nourished.

SEQUENCE OF EVENTS IN THE DEVELOPMENT OF CANCER

If it were possible to preserve a record of the condition of the mucous membrane of the rectum for several years before the appearance of a malignant tumor, we believe that in the majority of cases the following stages would be noticed in sequence, though naturally the number of years elapsing between each stage would vary greatly from patient to patient: *First stage*, localized patches of hyperplasia invisible to the naked eye but discoverable with the microscope, affecting an extensive area of the bowel. *Second stage*, the appearance of a crop of sessile adenomata scattered over as wide an area as was affected by the initial hyperplasia. *Third stage*, the development of cancer, either in one of these pre-existing adenomata (Fig. 4) or in the neighboring epithelium. *Fourth stage*, the progressive enlargement and dissemination of the malignant tumor accompanied by retrogression of the hyperplastic changes and benign tumors surrounding the malignant growth.

THE PRECANCEROUS STATE

Both experimental and clinical observation have shown that the onset of carcinoma is commonly preceded in different organs of the body by a precancerous condition of the epithelium. In the rectum, this precancerous state is distinguished by irregular patches of hyperplasia of the mucous membrane and adenomatosis. This does not mean every patch of hyperplasia will evolve into an adenoma, or every adenoma into a cancer. The hyperplasia may disappear, an adenoma may become pedunculated and be shed; or

Fig. 5. Cancer of the rectum accompanied by adenomatosis. Note the small size of the malignant growth (indicated by the arrow) and the adenomatosis extending over the entire surface of the rectum. Localized epithelial hyperplasia was also widespread, but this change is not visible to the naked eye.

at any stage the onward march may be arrested. In experiments upon mice, we find that not every mouse painted with tar develops papillomata and not every papilloma becomes an epithelioma; nevertheless, we can say that the common sequence of events when mice are tarred is hyperplasia, papilloma, and epithelioma. The papilloma is the precancerous stage in experimental tar cancer and the adenoma is the precancerous stage in human rectal cancer.

We cite the following clinical evidence in support of this assertion.

CLINICAL EVIDENCE IN SUPPORT OF CONCEPTION OF A PRECANCEROUS STATE

The following cases illustrate what we regard as stages in the development of cancer of the rectum.

CASE 2. A patient, 66 years of age, was admitted to St. Mark's Hospital with complaint of bleeding from the rectum. The first symptom was noticed only 14 days previously when, after an urgent call to defæcate, the patient observed that he had passed a little blood. Sigmoidoscope examination showed a small tumor in the rectum. A perineal excision was performed.

The piece of intestine removed at operation is shown in Figure 5. The tumor was about 1 inch in diameter and projected ¼ inch above the surface of the bowel. The mucous membrane of the rectum above and below was covered with adenomata, most of them about ⅛ inch in diameter. When the mucous membrane was stripped off the submucosa, it was obvious that the tumors consisted entirely of an epithelial hyperplasia and were not caused by a bulging inward of the submucous coat. Nine adenomata could be counted in 1 square inch of the bowel above the growth, and they were almost equally numerous elsewhere.

Microscopic examination showed the central tumor to be an adenocarcinoma. The cancer cells were seen to have invaded the submucosa but none was found within the muscle wall. The small tumors round about were seen to be composed of glands of mucus secreting epithelium and were true adenomata.

This case is specially noteworthy because of the early stage of the cancer, as shown by its small size and brief history, and because of the widespread adenomatosis, which we believe to be a special feature of early malignant disease of the bowel.

CASE 3. A patient, 47 years of age, was admitted to St. Mark's Hospital complaining of bleeding from the rectum. He gave a history of bleeding and loose movements for about 3 months. Cancer of the rectum was diagnosed by sigmoidoscopic examination and a perineal excision was performed.

The specimen removed at operation is shown in Figure 6. The cancer had the appearance of an oval shallow ulcer, 2½ inches in diameter, extending half way round the bowel wall. The mucous membrane above the growth was dotted with adenomata, there being on the average 6 to 12 tumors per square inch. They were less numerous below but could be seen almost as far down as the mucocutaneous junction. Microscopic examination showed the tumor to be an adenocarcinoma infiltrating the muscle wall of the bowel. The adenomata had the same microscopic characters as those of Case 2.

CASE 4. A patient, 67 years of age, was admitted to St. Mark's Hospital complaining of losing weight for 7 months and diarrhœa with increasing loss of blood and mucus. Cancer of the rectum was diagnosed and a perineal excision performed.

The piece of intestine removed at operation is shown in Figure 7. In the upper part of the rectum

Fig. 6. Cancer of the rectum associated with adenomatosis. Note the extensive area of the bowel which is covered by the benign tumors and the comparatively small area affected by malignant disease.

was a large fungating ulcer, 3½ inches in diameter, which had extended almost completely round the bowel wall (tumor A). At the lower extremity of the rectum was another large irregular fungating growth extending completely round the bowel and obviously composed of 3 or 4 separate tumors united into one mass (tumor B). Between these large upper and lower tumors, 3 other separate tumors, ½ to 1 inch in diameter, projected from the bowel wall. The intervening portions of the bowel wall appeared to be healthy. Microscopic examination showed the upper and lower tumors and the largest of the 3 intermediate tumors (tumors C) to be adenocarcinomata, the submucosa beneath each being invaded by malignant cells. The other tumors showed no indignant changes. Thus in this case, 3 separate malignant growths and several benign adenomata were present in the rectum, and sigmoidoscopic examination revealed other tumors in the sigmoid flexure of the colon.

Multiple foci of cancer in the rectum are not common. We have collected a few specimens at St. Mark's Hospital of 2 separate malignant growths, but this is the first instance of 3 malignant growths in the rectum.

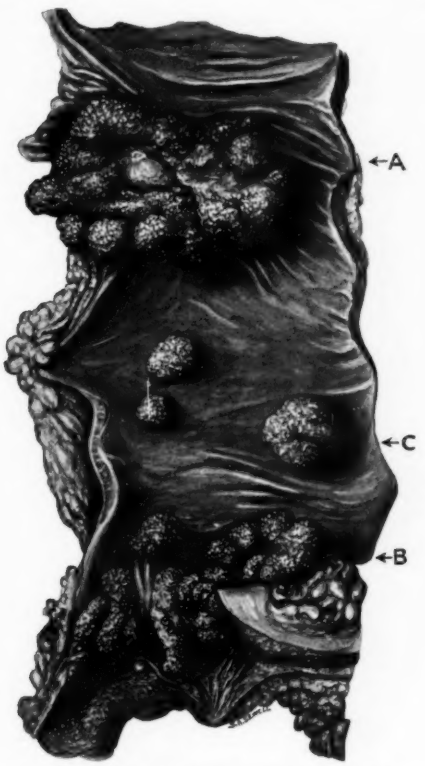

Fig. 7. Cancer of the rectum accompanied by adenomatosis. In this case, 3 separate malignant tumors, *A*, *B*, and *C*, are present. Beneath each the submucosa is invaded by cancer cells, but the intervening tissues show no infiltration. This is a case of cancer supervening on adenomatosis, the malignant disease commencing at 3 separate places.

The following case illustrates the extensive area of bowel which may be affected by adenomatosis and the value of the discovery of adenomata as suggesting neighboring malignant disease.

CASE 5. The patient was a gentleman, 58 years of age, who came to have a large pedunculated adenoma removed from the rectum. At operation, an adenoma, as large as an orange, with a long pedicle, attached about 4 inches above the anus, was easily removed. It was then discovered that there was another adenoma quite as large as the first impacted in the upper part of the rectum. This was removed with considerable difficulty, as although it was pedunculated it was so large that at first it could not be pulled past its own pedicle which was attached below it. After the removal of the second adenoma, a sigmoidoscope was passed

and a third adenoma as large as the others was seen in the sigmoid flexure. The abdomen had to be opened so that this adenoma could be removed. It was situated in the lower third of the sigmoid colon and part of it had undergone malignant change and involved the bladder wall.

As an illustration of the fact that adenomata occur as the result of a hyperplastic change which has affected an extensive area of the mucous membrane, the following case is of particular interest:

CASE 6. A gentleman, 62 years of age, came for treatment of a large adenoma high up on the posterior wall of the rectum. Local removal of the mucous membrane including the adenoma was made and the patient has been carefully watched since. During the course of 6 years from the time of the original operation, four adenomata have been removed at different times. None of these adenomata was in the strict sense a recurrence as none of them arose in the situation of the original tumor, but in other parts of the rectal mucous membrane some distance away.

Another exactly similar case has been under observation for 5 years and 4 different tumors have been removed, none of which was in the situation of the first tumor.

Had these patients not been examined at regular intervals, large tumors would have developed which would have been certainly looked upon as true recurrences. The truth seems to be that adenomata once removed do not tend to recur in the same spot, but other adenomata tend to develop in the neighboring mucous membrane. In other words, they arise as the result of the occurrence of progressive hyperplastic change not in one spot, but in a fairly extensive area of the bowel epithelium.

If this view of the sequence of events is correct, the condition we have described as multiple adenomata is one that should be watched most carefully. One of us has shown in an article on "Cancer and Heredity" how frequently cancer is associated with multiple adenomatosis and has explained the apparent hereditary tendency to rectal cancer in certain families as due to the familial incidence of multiple adenomatosis. Since multiple adenomatosis is so frequently an early stage in the development of cancer, it is imperative that a patient in whom this condition is discovered on sigmoidoscopic examination should be kept under strict observation.

SUMMARY

The earliest recognizable lesion in the development of cancer of the rectum is a hyperplastic change taking the form of irregular epithelial proliferations, scattered over an extensive area of the bowel.

This is followed by the appearance of visible tumors—adenomata: these are usually numerous and often separated from each other by several inches of mucous membrane normal in appearance to the naked eye. We have called this the precancerous stage.

The bowel may remain in this condition for many years, or at any stage in the epithelial proliferations, or at any stage in the growth of an adenoma the epithelium may abruptly assume those invasive properties recognized clinically and histologically as cancer.

It would appear that carcinoma formation is an accident happening to a previously existing adenoma. With the development and dissemination of the malignant tumor, the neighboring epithelial proliferations and benign tumors tend to retrogress and disappear so that they are less evident in association with large malignant ulcers.

These opinions are supported by pathological and clinical observations.

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THE FATE OF IODIZED OIL (LIPIODOL) IN THE LUNGS

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THE introduction of iodized oil in the form of lipiodol into the field of radiology by Sicard and Forestier (6) in 1922 has been followed, especially of late, by its widespread use in the exploration of the bronchial tree. Reports are now available from numerous clinics where fairly large series of cases have been injected. But scientific therapeusis presupposes an intimate and exact knowledge of the physical and physiological effects upon the organism of the substance administered, from the moment it enters the body until its elimination is completed. Although as a rule the use of a drug is to be deplored when this knowledge is incomplete, still, if the drug has been shown to possess certain advantages, then its use must be condoned until further light either strengthens or weakens the authority for its administration. This is the present state of affairs with respect to the intratracheal injection of iodized oils.

It is known that certain dangers exist in the introduction of the material into the tracheobronchial tree (1). The knowledge of the absorption, elimination, and physiological action of the iodine component of the mixture is relatively complete. But the same cannot be said of the oil portion. Therefore the experiments reported in this article were undertaken with the aim of studying (a) the reaction, if any, of the finer structure of the pulmonary tree to the presence of iodized oil, and (b) the fate of the oil portion of the combination. In these experiments the French preparation, lipiodol, was employed. This consists of a vegetable oil, "huile d'oeilette," and contains besides 40 per cent of iodine by weight. The iodine is said to be in chemical combination with the oil, which combination breaks up slowly once the oil is in the body, but is otherwise fairly stable. Forestier has shown that after an intratracheal injection of 20 cubic centimeters of lipiodol, the daily elimination of iodine (mainly via the urine), during the first 2 weeks is about 2 centigrams. The iodine makes its appearance in the urine in about 10 hours.

The recent work of Roger and Binet (4) suggests that the lung possesses, besides its usual function of filtering gases, an internal digestive power, which is most strikingly exhibited in its action on fats. In their investigation they make use of intravenously injected oils, and they believe that the fat is altered by a true intravascular digestion in which oxidation plays the most important rôle. Their observations, however, were concerned with the fate of oil on the blood vessel side of the air-capillary membrane, while we are dealing with oil introduced into the air side of this system. The experiments of Guieysse (3) extended and confirmed by Guyot, throw some light on this phase of the problem. They injected small amounts of purified olive oil intratracheally into the lungs of rabbits and made histological preparations of the lungs 1 and 4 days after the introduction. They found that after 24 hours the drops of oil in the alveoli were in a state of decomposition, were irregular, jagged, and filled with vacuoles, and that by the fourth day this process was still more marked. They believed the oil to be absorbed by the epithelial cells of the alveoli. However, when they used larger doses of oil, they found that a certain number of the epithelial cells, detaching themselves from the alveolar wall, phagocyte the oil, and migrate through the adventitia as far as the lymph nodes. On the other hand, Sicard (6) states that the oil which remains in the lungs for longer periods of time probably becomes encysted. It seemed to the writer that further experimental work in this direction was worth while.

EXPERIMENTAL METHOD

Lipiodol was introduced into the tracheobronchial tree of cats under light general anæsthesia by the intercricothyroid route. A small syringe was first attached to a heavy needle and the latter inserted into the

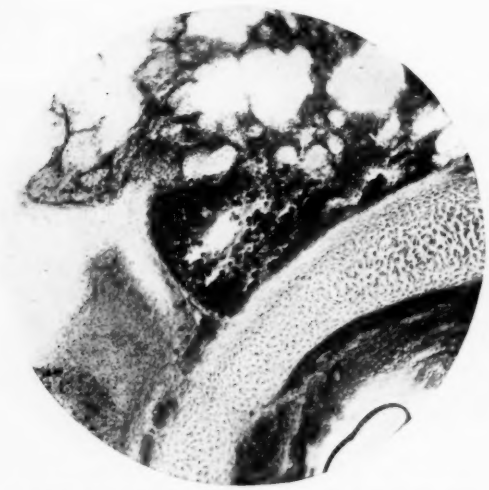

Fig. 1. Cat 4. Photomicrograph in the region of a fair-sized bronchus showing in the center of the field a dense collection of mononuclear phagocytes filled with globules of oil. The cartilage and a bronchial wall are noted from 3 to 6 o'clock and empty alveoli above. Lens, 16 millimeters; ocular, 8 times; bellows, 15 inches; stain, Sudan III.

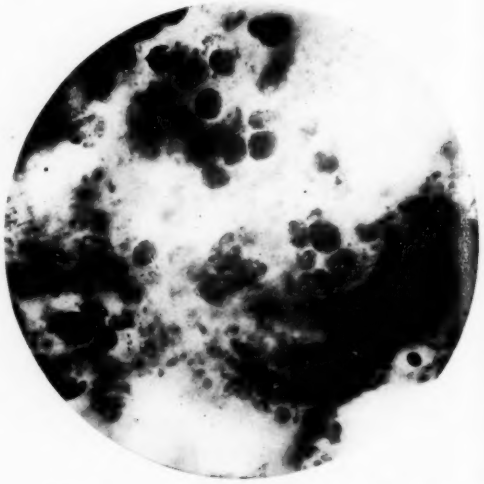

Fig. 2. Cat 4. Photomicrograph of a portion of the mononuclear cell collection seen in Figure 1, showing the fine state of division of the phagocytized oil. Oil immersion lens; 8 times ocular; bellows, 20 inches; Sudan III stain.

trachea, its position being determined by the free aspiration of air into the syringe. This syringe was then replaced by another containing warmed lipiodol, and 2 cubic centimeters of the oil were introduced. The injection was carried out with the cat fastened upon an animal board and placed on an inclined plane of 30 degrees head up, so as to facilitate the flow of the oil into the finer bronchi. In some instances cough was induced shortly after injection. The trachea was compressed at the same time, as this procedure has been shown to further the penetration of the oil (2). X-ray pictures were taken in each case shortly after the injection, to make clear the presence and general position of the oil in the tracheobronchial tree, and were repeated at intervals of 1 to 3 days throughout the remainder of the life of the cat, the excellent radiographic properties of the oil rendering it peculiarly adaptable to this phase of the work. The cats were then killed by bleeding, at various intervals from ½ hour to 26 days after injection, and autopsied, the lungs in each case being preserved in 10 per cent formalin. A glance at the last X-ray picture of the lung in question usually demonstrated the portion of the lung containing the oil in greatest amount, and histological sections were taken through that area in which the presence of the oil had been demonstrated at some previous time. Two series of slides were made, one the usual hæmatoxylin and eosin preparation to demonstrate any cellular reaction, and the other frozen sections stained with Sudan III or Scharlach R, and mounted in Farrant's solution, to demonstrate the oil itself. The sections were cut thick (25 to 35 microns) so that the larger droplets of oil would not fall out.

The detailed, typical, and histological, findings in these experiments were carefully noted. In all cases, roentgenograms taken shortly before the death of the animal demonstrated the iodine component of the oil to be present in larger or smaller amounts. Actually this amount appeared to vary, as seen by subsequent microscopic examination, in direct proportion to the amount of oil found in the tissues. That is, although the absorption and elimination of the iodine proceeds at a more rapid rate than the oil, still the more oil there

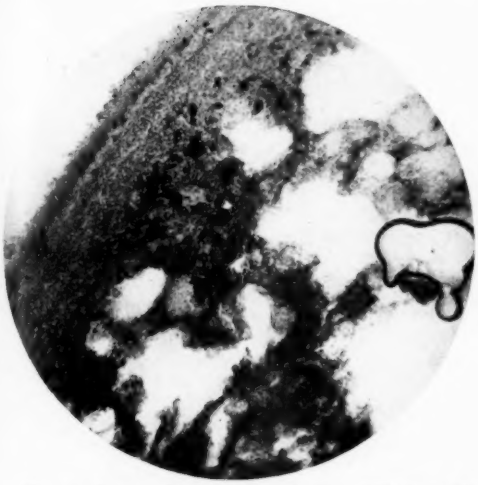

Fig. 3. Cat 4. Photomicrograph of a portion of the pleura. The dark staining elements collected especially just beneath the pleural surface are mononuclear phagocytes filled with droplets of oil. Lens, 16 millimeters; 8 times ocular; 20-inch bellows; Sudan III stain.

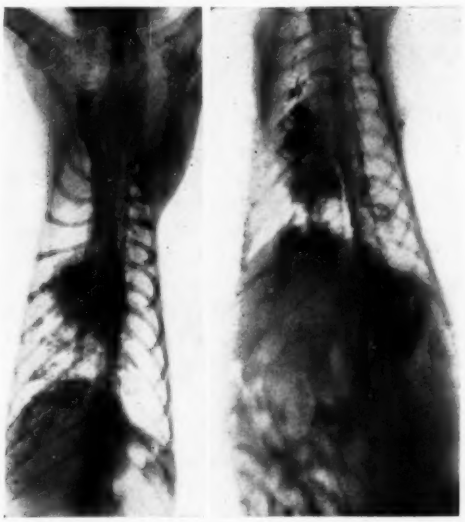

Fig. 4 (left). Cat 4. Twenty-four days after the lipiodol injections. In this cat, 2 injections were performed at the outset, the first intratracheally and the second into the subcutaneous tissues of the neck. That in the lungs still persists in a finely spread state in the middle and lower right lobes. It is from this area that sections were taken for microscopic examination. The mass in the neck is well defined and microscopic sections here show the oil to be well encapsulated. No such process of encapsulation was noted with respect to any of the oil in the pulmonary tissues.

Fig. 5. Cat 1. Four days after the introduction of lipiodol. Roentgenographic shadows show the oil to be present in large amounts in the middle and lower right lobes. Sections for microscopic examination were taken from this area.

is in the tissues the more iodine is also present.

From these histological studies it appears that phagocytosis is a prime factor in the absorption of oil from the alveoli, and that these phagocytes then transport the material by way of intercellular migration to lymphatic channels and lymph nodes. The cells concerned in the process of phagocytosis are large mononuclear cells, apparently of endothelial origin. In the earlier days after introduction of the oil, these cells are most prominent in the neighborhood of the oil-filled alveoli and in the alveolar spaces themselves, while, as the process progresses, they are observed also in large numbers collected in groups in the lymphatic areas and nodes, and finally, even after the alveolar spaces have got rid of the oil, these groups of phagocytic cells containing the oil still stand out prominently.

It was noted that the distribution of these oil containing phagocytes during the process of migration (Fig. 1) closely follows that of the lymphatics of the lung as described by Schaefer (3). The passage reads as follows:

"*Lymphatics.* The veins are accompanied by lymphatics, which commence both in the interalveolar tissue and under the pleura, and pass to lymphatic glands at the root of the lung. Others, which eventually join these, accompany the arteries, and others are found in the walls of the bronchial tubes. There are no lymph-vessels distal to the lobular bronchioles. The lymph-vessels of the bronchi send branches to join those of the pulmonary arteries and veins: these communicating branches come from the end of the lobular bronchioles and from the places where the bronchial tubes branch. The atria and infundibula (air-sacs) have no lymph vessels in their walls. The lymphatics of the lung often contain large mononuclear leucocytes (phagocytes) with carbon particles in their interior. The carbon particles are introduced with the air of respiration and appear to be conveyed

from the interior of the alveoli into the pulmonary tissue by the agency of leucocytes, which are often seen, in sections of lung, within the air-cells" (Fig. 2).

The rate of removal of the oil appears to be in direct proportion to the number of these phagocytic cells which may be marshalled into action in any given area. Thus, if there be only a small amount of oil in a given region, it is quickly removed; whereas, if many neighboring alveoli are filled with oil, the process is markedly prolonged, probably because of the lack of sufficient phagocytes to expedite the work as well as of a mechanical block of tissue and lymphatic spaces (in which the phagocytes migrate) by the pressure of the oil (Fig. 3).

In no instance, even when oil was found in alveoli after a period of 4 weeks, was there any evidence of encapsulation of the oil. This encapsulation has been suggested as being the fate of oil remaining in the lungs for long periods of time, but we are unable to adduce any confirmatory evidence on this point. In contrast to this we have observed encapsulation of masses of oil injected into the intermuscular spaces of the neck to take place as early as 1 week after the introduction of the oil.

Although the most important factor in the removal of the oil appears to be a process of phagocytosis, comparable to the removal of dust particles from the alveoli, there is probably also a certain amount of direct absorption of oil by the lining cells of the alveoli themselves, but this appeared to be of secondary importance. Perhaps there is also a certain digestion of oil and absorption into the blood system as suggested by the work of Roger and Binet, but there is no evidence in support of this in the material at hand, nor did we note any vacuolization of the oil in the alveoli as suggested by Guieysse.

DETAILED HISTOLOGICAL FINDINGS

CAT 1. (Autopsy 4 days after introduction of oil.)

A. (Slides stained for oil) Lipiodol is scattered in a state of fine division throughout numerous alveoli, some of which are completely filled with the oil. Apparently oil is also absorbed by the endothelial cells of the alveoli and is collected in large masses in the connective tissue around the smaller bronchi and pulmonary veins. Nowhere do droplets of oil appear vacuolated. In those areas where lipiodol is found in greatest amounts there is a marked infiltration of leucocytes most of which are mononuclear, several being of the large phagocytic variety, and many of which show oil inclusions. In some areas the pleura shows collections of the oil in a very fine state of subdivision. Here also it is mainly present as inclusions within large mononuclear phagocytes.

B. (Hæmatoxylin and eosin slides.) Small hæmorrhagic areas are scattered throughout the lung along with the cellular infiltration of the tissues, which is predominantly mononuclear in character. In the same areas are noted masses of yellow brown staining material which is similar to hæmosiderin in appearance. This cellular infiltration is especially marked around the pulmonary vessels and bronchi. No thickening of the pleura is noted, although the infiltration and hæmorrhage extend directly up to the pleural surface.

CAT 23. (Autopsy 24 hours after introduction of lipiodol.)

A. (Slides stained for oil.) Large areas of the sections examined show many of the alveoli completely filled with the oil and others containing it in greater or smaller amounts. Throughout the involved areas a moderate leucocytic infiltration, primarily of the large mononuclear variety, is noted. The cytoplasm of many of these cells is filled with minute droplets of oil. In some instances these cells are observed in what may be supposed to be the actual process of phagocytizing the oil. However no vacuolization or puncturing of the large droplets by these phagocytes is noted. The phagocytic cells are observed both free in the alveolar spaces and also apparently in the process of migration through the pulmonary tissues. In those areas in which only a few of the alveoli have been filled with the oil the process of phagocytosis has proceeded most rapidly, and here also are noted large numbers of phagocytic cells. These cells are likewise collected in groups about the walls of the bronchi. Immediately beneath the pleura collections of the oil containing mononuclear phagocytes are also seen.

B. (Hæmatoxylin and eosin slides.) In some areas there is a marked mononuclear infiltration. These cells correspond to the phagocytic type and are found in greatest numbers about the walls of the alveoli and in several instances in large amounts free within the alveolus. A few of these cells contain one or more vacuoles. They are also noted scattered just beneath the visceral pleural surface.

CAT 4. (Autopsy 24 days after the introduction of lipiodol.)

A. (Slides stained for oil). Small droplets of oil are scattered throughout large areas of the lung. Many of the alveoli are almost completely filled with phagocytic leucocytes in whose cytoplasm numerous fine droplets of oil are noted. In some instances the whole cellular structure of the lung is apparently permeated with these very fine droplets. About the

nuclei of the cartilage cells and in the cytoplasm of these cells are collections of oil. The pleura is thickened and covered with an exudate which likewise contains large amounts of oil finely subdivided. In some areas there is evidence of old hæmorrhage and throughout the regions involved there is observed leucocytic infiltration, predominately mononuclear in character.

B. (Hæmatoxylin and eosin slides.) The areas about the pulmonary vessels and bronchi show a marked infiltration in which large mononuclear cells predominate. The pleura is thickened and infiltrated throughout with these cells. In other portions the lung has completely lost its structure and contains miliary abscesses.

SUMMARY AND CONCLUSIONS

An iodized oil (lipiodol) was injected intratracheally in 2 cubic centimeter amounts into the lungs of healthy cats. These cats were killed anywhere from ½ hour to 26 days after the introduction of the oil, and histological studies of the lungs undertaken. From these studies it appears:

1. That the presence of oil in healthy alveoli excites a mononuclear infiltration of the area involved;

2. That this mononuclear infiltration is of the large phagocytic type, apparently endothelial in origin;

3. That these phagocytes are the prime agents in the removal of the oil from the alveoli and that they follow the lymphatic system, while direct absorption or digestion of the oil, if it occurs at all, is of secondary importance;

4. That at least up to 4 weeks, there is no evidence of encapsulation of the oil remaining in the alveoli; and

5. That the rate of removal of the oil is in direct proportion to the number of available phagocytes.

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FURTHER STUDIES ON CLOSURE OF BRONCHI IN LOBECTOMIES (EXPERIMENTAL WORK)

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IN a paper written by one of us several years ago,[1] experimental evidence was advanced to show that it is difficult to close bronchial stumps after pneumectomy because the structures which go to make up the stump are in themselves unable to close the bronchus. When a bronchial stump heals it does so usually because of the activity of some extrabronchial tissue, most frequently the pleura from adjacent lobes. In our experiments at that time we reported a series of dogs in which after a complete pneumectomy, the vast majority died suddenly on the fifth or sixth day because of the failure of the bronchial stump to heal. It took about 5 days for the ligature which closed the bronchus to slough and allow the bronchus to re-open. As long as the bronchus was held closed by the ligature the dogs were in good condition. As soon as the stump sloughed and the bronchus re-opened the dogs died from internal pneumothorax. In this series one dog survived and later was killed. Microscopic section showed that the bronchial closure was accomplished by a very thin membrane and it was a source of surprise to us that the membrane had not torn on the first paroxysm of coughing.

In this same article we reported a second series of experiments, in which, instead of removing the entire lung on one side, we removed only one or two lobes of the lung leaving one or more lobes in place. The great majority of our dogs lived. On autopsy it was found that the bronchial stump had become buried in adhesions usually derived from the pleura of contiguous lobes, and that these adhesions derived from peribronchial tissue had closed the stumps, the actual tissues in the stump itself had not been active in the healing process. We made the statement at that time that although the main bronchus was extremely difficult to close and that complete one-sided pneumectomy almost invariably resulted in death on the fifth or sixth day, due to opening of the stump, a lobectomy on the other hand was easily tolerated. This second statement of ours has been frequently misquoted, so frequently that we deemed it advisable to perform a new series of experiments to prove our conclusion that lobectomy in a dog is easy to perform and well tolerated, and that the bronchial stump is closed by being firmly embedded in adhesions derived from peribronchial tissue.

The work here to be reported consists of 3 series of experiments.

1. A series of lobectomies, carefully done, with insufflation anæsthesia, the main bronchus being ligated to a lobe with silk or catgut, the vessels to the same lobe ligated separately with silk or catgut, and the lobe being amputated just distal to the ligatures.

2. A series of lobectomies, less carefully done, both vessels and bronchi being ligated with the same mass ligature and an appreciable amount of tissue being left distal to the ligature. Open drop ether was used for this series.

3. One dog in which a careful complete one-sided pneumectomy was performed.

Series 1 consisted of 7 dogs. Anæsthesia was obtained by intertrachial ether insufflation. The chest cavity was entered by an intercostal incision. One or another lobe of the lung was grasped and delivered into the wound. With a small aneurism needle, the vessels and bronchus were caught and ligated separately and the lobe was amputated. Only enough tissue was left distal to the ligature so that the ligatures would not slip. After the lobe was amputated the lungs were inflated and the wound was closed. In some instances the interspace was closed by approximating the ribs with catgut sutures, in others the muscles only were sutured. The skin was closed by means of an intracuticular stitch and colloidin.

Of these 7 dogs, only 1 died from a re-opening of the bronchial stump. This dog died on the fifth day and presented the same findings as in our previous

[1]Experimental closure of large bronchi. By Ralph B. Bettman, M.D. Arch. Surg., 1924, viii, 418.

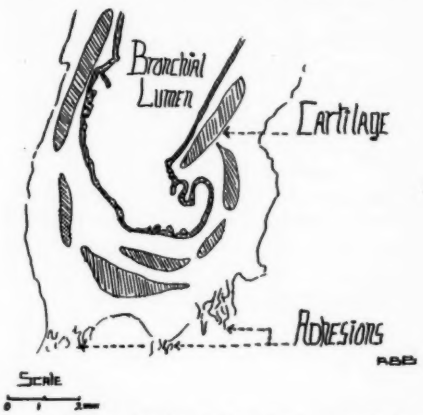

Fig. 1. Camera lucida tracing from a typical case (Series 1, Dog 2) showing the dense adhesions which bury the stump. The stump is blunt. The mucosa has completely regenerated. The cartilage at the tip of the stump stains very faintly and is probably cartilage which was turned over by the crushing action of the ligature.

reports, namely a clear pleural space, no emphysema, no free fluid in the pleural cavity but a widely open bronchial stump; death was sudden, and due to internal pneumothorax.

One dog died on the fifth day but to our surprise not only was the pleural cavity clear but the bronchial stump was closed and the lung could be inflated with a syringe without any leakage of air. Careful autopsy showed no pathological conditions which might have caused death. The cause of death, therefore, was not determined.

The 5 remaining dogs all survived, were well, and were killed 23, 46, 53 and 60 days respectively after operation.

On examination the pleural cavities were found normal, no adhesions were present except in 2 dogs in which a fine, string-like adhesion rose from one of the lobes to the site of pleural incision. The pleural scar in all dogs was barely discernible. The lungs filled the pleural space. The bronchial stump was very difficult to find, the stump being buried in adhesions and usually covered by one of the remaining lobes of the lung.

In short, in this series, the majority of our dogs survived lobectomy, and the stump was found to have been buried in adhesions. Therefore, we again maintain as do practically all other writers, that dogs survive lobectomies and the closure of the bronchial stump is aided by connective tissue derived principally from the surrounding structures, adjacent lung lobes.

SERIES 2 consisted of 6 dogs. Lobectomy was performed by mass ligature and a larger (than in Series 1) amount of ligated stump tissue was left. The operation consisted of an intercostal thoracotomy, a lobe being delivered through the wound, the hilus of the lobe being ligated, and the lobe being amputated in such a manner that a fairly large amount of lung tissue remained distal to the ligature. Four died from the re-opening of the bronchial stump, 2 on the sixth day, 1 on the eleventh, and 1 on the eighteenth. The 2 other dogs who survived this period died of distemper, 1 on the twenty-first, and 1 the fifty-fourth day.

Fig. 2. The screw points to the bronchial stump of the amputated lobe deeply buried in adhesions.

The tissue distal to the ligature was thus deprived by ligation of the vessels of its blood supply and became necrotic. The necrotic tissue prevented the closing of the stump with the peribronchial tissue. We are aware that it is equally true that the necrotic tissue would have interfered with the healing of the bronchial tissues themselves and therefore we are not advancing this as an argument to prove the nonhealing qualities of the tissues. We performed this series of experiments because we thought that the remaining pleura would be able to block off the bronchial stump even in the presence of necrosis and that the pleura would be sufficiently resistant to cope with the small amount of infection

TABLE I

First Group	7 dogs	Lobectomy	Dissection of main bronchus to lobe. Separate ligation of blood vessels. Careful asepsis. Intratrachial anæsthesia.
Results			Open bronchial stump 1—5 dogs killed. Lungs clear; stump closed and buried in adhesions, 60–53–53–46–23 days. Died; cause unknown stump closed 5th day 1. 1 died opening bronchial stump 1 died cause unknown, stump closed. 5 survived and were killed. Stump closed.
Second Group	6 dogs	Lobectomy	Mass ligature, no artificial pneumothorax. Tissue distal to ligature. Open bronchial stump 5–6–11–18. Closed stump 21–45 (Distemper).
Third Group	1 dog	Pneumectomy	Died 5th. Open stump

present. However, in two-thirds of our cases this was not found. We thought that perhaps on the other hand if the bronchial tissues did heal of their own accord we might have the stump lying free in a small walled off space.

SERIES 3, consisted of 1 dog in which a complete one-sided pneumectomy was performed. The dog died on the sixth day from re-opening of the bronchial stump. This dog acted in a manner similar to that observed in the large series published in our previous article and the case requires no further comment. We did not feel justified in sacrificing more dogs to prove that the bronchial stump fails to remain closed in pneumectomies (in contradistinction to lobectomies).

SUMMARY

In our hands as in the hands of most experimenters, lobectomy in dogs is an operation easily performed and well tolerated. The stump remains closed, the pleura does not become infected, and the dogs themselves appear none the worse for the loss of the small amount of lung tissue. We think that the adjacent pleura and the peribronchial tissues play a major rôle in the closing of the stump.

In the first series, lobectomy was done in 7 dogs—under intratracheal anæsthesia, dissection of the main bronchus to the lobe and separate ligation of the blood vessels. Careful asepsis was observed throughout. In this group 1 dog died from re-opening of the bronchial stump; one died on the fifth day but the stump was closed and buried in adhesions. Five dogs were killed 23, 46, 53, 53 and 60 days, respectively, after operation.

In the second series of experiments, lobectomy was done in 6 dogs—mass ligature with an appreciable amount of tissue left distal to the ligature. Four dogs died from re-opening of the bronchial stump, 5, 6, 11, and 18 days after operation. The other dogs died of distemper 21 and 54 days after operation.

In the third series, pneumectomy was done in one dog which died on the sixth day from re-opening of the bronchial stump.

THE ANATOMICAL BASIS FOR THE STUDY OF SPLANCHNOPTOSIS

The Abdominal Walls at Term

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OUR knowledge of the prenatal evolution of the abdominal walls is still incomplete. It is known that the viscera are developed first. Later, these are surrounded by a membranous wall into which, still later, from the dorsal toward the ventral surface wander the muscles, these latter carrying with them their nerves and some of their blood vessels (F. P. Mall). The viscera withdraw within the walls and take up certain positions within the abdominal cavity thus formed. The walls surround the viscera and follow them in their changes, being more or less voluminous as the volume of the viscera is greater or less.

As the child develops within the uterus, it retains more or less of its dorsad convexity, the growing internal specialized parts (viscera) gradually becoming enclosed within the anterior concavity, while the growing external specialized parts (upper and lower extremities) turn forward and fold up upon the walls—the whole forming an ovoid mass suspended in fluid, the flexed head coming to be predominantly directed downward (Fig. 1).

As the child passes from this phase of existence, its liquid surroundings disappear, and as it is born it emerges unsupported by any close modifying medium into the wide ocean of the earth's atmosphere, and directly subject to the laws there existing. It tends to fall into a more or less horizontal plane, spontaneously assuming a supine, prone, or lateral position, or some combination of these positions.

THE ABDOMINAL WALLS AT TERM

When the child at term is laid upon a table, in the supine position, it tends spontaneously to assume a certain attitude, i.e., the dorsad convexity tends to disappear and the spine tends to straighten; the head falls to one or the other side in some degree of flexion and lateral rotation; the upper extremities fall to the side of the trunk in some degree of abduction, the elbows are more or less flexed; and the lower extremities assume an approach to the quadrupedal position, the thighs being more or less flexed, abducted, and rotated outward, while the knees are flexed so that the feet (heels) tend to approach each other in the median line (Fig. 2 a, b, g, h, i; Fig. 3 a, b, e, f, g, j; compare with Fig. 2 c, d, e, f).

Resistance is encountered if an attempt is made to change these positions to those assumed in the most advanced postnatal evolution of the individual, i.e., head midway between flexion and extension, so that the face lies in a plane parallel with the anterior plane of the trunk, and lower extremities extended, adducted, and rotated inward so that the patellæ look forward. Resistance is also met in abduction of the arms beyond a right angle with the trunk. If these resistances are overcome, the accomplishment of these later evolutionary positions is accompanied by changes in the trunk, including especially the abdominal walls.

Therefore, the study of the abdominal walls makes it necessary to study more or less the conformation of the child as a whole, i.e., certain details of the spine, thorax, pelvis, head, and upper and lower extremities. This study is first made in the spontaneous position, as already outlined, while later are noted the modifications which accompany the making of the advanced postnatal positions described.

THE TRUNK AT TERM

Shape of the trunk: anterior, posterior, lateral, and profile views. In the supine position, viewed from above, the general shape of

Fig. 1. Attempt to restore a child stillborn at term (9-XXII) to the intra-uterine position; profile view

Fig. 2. a. Same subject as in Figure 1; profile view. A fairly typical transition from Figure 1 to the spontaneous position assumed at term by letting the head and lower extremities fall to the supporting plane, the upper extremities remaining more or less folded across the chest. The head is flexed and rotated to one side; the lower extremities are flexed, abducted, and rotated outward. b, Photograph of a child stillborn at term (9-LIV), showing a fairly typical position of the legs at term, due to contractions of the firm fibrous tissues. c, Living dog (female) in the supine position viewed from above. The position of flexion, abduction, and outward rotation of the lower extremities is due to lateral musculocutaneous folds as well as to contractions of the deeper tissues. d, Photograph of a male chimpanzee which died almost as soon as it was born, showing position at term of marked flexion, abduction, and outward rotation of the lower extremities. e, Photograph of a female orang about 2½ years old, showing flexion with extreme abduction and outward rotation of the lower extremities (thighs). f, Photograph of an orang about 3 years old, showing functional usefulness in subhuman existence of extreme flexion, abduction, and outward rotation of the lower extremities. g, Photograph of a living child, 10 days old (B6 a). The position of marked flexion, abduction, and outward rotation of the lower extremities is a momentary functional reversion toward the earlier prenatal position. h, Photograph of a living child a few hours old (B11 b), showing fairly typical spontaneous position of the living child at term, and resembling the spontaneous position seen in the stillborn at term in 2 b. i, Photograph of a living child, 6½ hours old (B1 b). The position of extension, adduction, and inward rotation of the left lower extremity is a momentary organic progression in the transition toward the advanced postnatal position, as the contracted firm fibrous tissues are more and more stretched in the postnatal evolution of the human type. Note the compensatory forward and downward rotation of the pelvis, the lumbothoracic lordosis, the anterior abdominal protrusion, and the forward and upward rotation of the thoracic cage.

(d, e, and f, photographs through courtesy of New York Zoological Park.)

the trunk is bluntly fusiform and flattened more or less from before backward (in the early hours after death, the abdomen is usually more or less rounded anteriorly as well as laterally); sometimes the central enlargement is prolonged upward and downward, resulting in a barrel-shaped figure; sometimes, the lower pole of the spindle is enlarged laterally, giving a square or rectangular shape to the lower trunk. The lower pole of the spindle appears to be bounded in front by the suprapubic groove, and the trunk appears to terminate in a "waist" which is marked anteriorly by this line and laterally by the apex of the trunk-thigh lateral angle (Fig. 2 b, g; Fig. 3 a, e, f).

The upper limits of the trunk are obscured and made to appear square or rectangular by the shoulder girdle and the muscles connecting the trunk with this girdle. When the shoulder girdle is removed, the true shape of the upper pole of the trunk is seen, and the upper pole of the spindle is seen to be the smaller (Fig. 3 d; compare with c, e).

Viewed from the side, the front profile of the trunk (Fig. 3 f to j) shows an anterior curve which is markedly ovoidal, the convexity of the curve rapidly increasing from the sternal notch downward, to reach its maximum in the neighborhood of the lower end of the gladiolus or the upper epigastric region. From here, the curve as a whole rapidly decreases as it passes downward to the symphysis, though sometimes it is broken by a slight secondary convexity near the umbilicus. In this position, the child appears to rest upon the table in an unbroken line from occiput to buttocks, the lateral walls of the abdomen tending to project more or less laterad and dorsad, obscuring line of spine.

In the *prone* position, viewed from above (Fig. 4 a, b), the entire back appears square or rectangular, narrowing downward as to a "waist" at or just below the crests of the ilia, at the trunk-thigh lateral angle. This apparent waist line marks the lower pole of the spindle and is continued anteriorly by the suprapubic groove. It is also marked mediad by a more or less pronounced receding angle opening dorsad (lumbosacral angle), with more or less irregular transverse surface grooving. The lower pole of the trunk posteriorly (loins) is materially broadened or narrowed by the presence or absence of a pyramidal mass of fat which fills Petit's triangle and extends down over the upper part of the ilia to join the general increase of fat from there downward over the buttocks (Fig. 4 b).

As in the supine position, the upper limits of the trunk are obscured and made to appear square or rectangular by the shoulder girdle and the muscles connecting the trunk with this girdle. When the latter is removed, the true shape of the upper pole of the trunk is seen, and the upper pole of the spindle is again seen to be the smaller (Fig. 4 c).

Viewed from the side, the back profile (Fig. 4 d, e) shows a long oblique line, or a long, very slight curve with convexity dorsad. In either case, the line is limited by two slightly receding angles, with apices directed ventrad, the upper angle being at the junction of the head with the trunk, and the lower a little below the crests of the ilia (lumbosacral angle). Caudad to this latter angle, the continuing line rather brusquely becomes quite convex, because of the rounding dorsad of the buttocks. In this prone position, the front of the trunk rests on the table in an unbroken line from point on sternum below the notch where the bone falls into contact with supporting surface.

It is difficult to place the trunk in the *lateral* position, its tendency being to fall more directly prone or supine, according to the position and weight of the shoulder and pelvic girdles, and according to the position of the upper and lower extremities which enter into the supporting base.

The tendency is more toward the prone position, because of the tendency of the arm to fall forward and make traction in the same direction on the scapula and upper trunk. When the forearm is extended and the whole upper extremity placed directly on the side of the trunk, the latter seems to incline a trifle toward the supine position, on account of the weight of the scapula and its attachments.

When the trunk is balanced as well as possible midway between pronation and supination, and viewed from above, the anterior outline (front profile) of the trunk appears ovoidal, the longer arm of the curve being cephalad and extending from the neighborhood of the sternal notch to about the level of the ninth rib in the midaxillary line; from this point the curve may maintain its maximum or even slightly increase for a short distance, then it rather rapidly decreases to the symphysis pubis.

The posterior outline (back profile) may appear straight or it may show a slight posterior convexity extending from the base of the cranium to the end of the buttocks, this curve being broken at about the level of the crests of the ilia by a slight receding angle with its convexity anterior (lumbosacral angle). This receding angle varies in size with the degree of extension of the thighs upon the trunk. When the thighs are well flexed, this angle practically disappears and the straight line or posterior convexity of the spine may appear to be continuous. The posterior line may be modified by variations in the balance of the trunk.

Trunk markings. Viewed from the front, the salient trunk markings are the trunk-thigh lateral angle, the suprapubic groove, the groin grooves, secondary transverse grooves, variable muscle markings, variable periumbilical fat cushions, an occasional ensiform depression, and an occasional costal margin groove (Fig. 2 b, g, h, i; compare with c, d; Fig. 3 a, b, d, e).

The downward tapering of the trunk ends laterally at or just below the crests of the ilia. Here, an obtuse angle opening outward, and perhaps also more or less forward, is formed by the junction of the trunk and the thigh. The apex of this trunk-thigh lateral angle (which may be more or less blunted) is usually situated at about the level of the

junction of the upper and middle thirds of the distance from the crest of the ilium to the top of the trochanter (Fig. 3 a to j).

The *suprapubic groove* is most pronounced mediad, where it lies just above the top of the symphysis pubis; from here it is continued upward and outward in a curved line the concavity of which looks cephalad, to the neighborhood of the anterior superior spines; it then passes backward to the dorsum of the ilium and here is usually lost. If prolonged in the same direction, it would tend to reach the fourth or fifth lumbar spine. This groove was always found and it was always uniform, except in 1 case. In 6-XXXIII, it was unsymmetrical, its left half being displaced laterally. In this case, the right testicle had descended; the left lay low down in the inguinal canal, causing an ovoid swelling displacing the groove (Fig. 2 a, g; Fig. 3 a, b, c, e, f, j; Fig. 4 a to e).

On each side, the *groin groove* with a slight cephalad convexity approaches the suprapubic groove in the neighborhood of the anterior superior spine of the ilium; it then passes to the anterolateral surface of the thigh and curving downward and backward is more or less continuous with a line curving upward and forward from the region of the great trochanter, this latter line being marked by the abduction of the flexed and outwardly-rotated thigh. Sometimes, the suprapubic and the groin grooves are particularly well-marked through being reddened, with more or less superficial thinning or desquamation of the skin (Fig. 2 b).

There is sometimes a *secondary groove* running transversely across the abdomen 10 millimeters or more above the suprapubic groove, and there may be one or more similar but shorter grooves above or below this one; also there may be one or more above the umbilicus.

Sometimes a depression appears at the base of the *ensiform cartilage;* and sometimes a slight groove may be seen along the *costal margin* (Fig. 2 b, g, h).

Muscle markings are very variable, tending to be obscured by the layer of fat which at term forms a thick subcutaneous sheet over the whole body. When present, they appear more clearly defined in the erector spinæ mass and in portions of the abdominal rectus.

The thick subcutaneous layer of fat shows certain areas of marked increase, one of these areas being at times around the umbilicus—above, below, or laterally, suggesting more or less marked *peri-umbilical fat cushions.* There is also a marked area over the pubis below the suprapubic groove, this area merging with the general fat sheet over the anterior and internal thigh below the groin grooves (Fig. 3).

Other marked areas of fat noted are on the posterior surface—the back of the neck; the scapular area; the loins; and thence to the buttocks and the thighs. In the scapular area, the fat is more marked, more compact, and more difficult to remove along the vertebral border and inferior angle of the scapula; along the spine of the scapula where the trapezius and deltoid come into juxtaposition; and along the external border of the scapula, obscuring the edge of the latissimus. There is a triangular space covered and filled in by fat, "stuffed-in," as it were, between the upper edge of the latissimus, the lower edge of the trapezius, and the vertebral border of the scapula, the floor of the triangle being formed by a portion of the rhomboideus major, one or more ribs with their intercostals, and a portion of the sacrospinalis. The trunk triangle formed by the trapezius is especially outlined by fat, also the lower median line of the triangle, and especially the neighborhood of the apex. In the loins, Petit's triangle is so filled with a pyramidal mass of fat (base dorsad) as to broaden the loins and make the external contour quite smooth, as it merges with the thick subcutaneous sheet of fat. Here, in the lower back, this sheet extends especially over the crest of the ilium toward the posterior inferior spine, and downward and forward a little below the crest, in the trunk-thigh lateral angle. Less thick over the upper part of the gluteus maximus, it rather quickly increases from above the acetabulum downward over the posterior thigh and the buttocks, also over the thigh generally (Fig. 4).

Longitudinal trunk planes. The trunk is bounded by four longitudinal planes: anterior, posterior, and two lateral. On dissecting away the skin, superficial fascia, and all the muscles covering the spine and ribs, but leaving intact the abdominal muscles (including the quadratus lumborum), leaving also the ligaments and articulations intact, and then removing the shoulder girdle, these planes are seen more distinctly.

The anterior plane (supine position) consists above of the sternum and the sternal cartilages. It is bounded laterally by the junction of the ribs with the sternal cartilages, and broadens from above downward. It is distinctly marked down to about the eighth rib, it is less distinct at the ninth rib, and below that it cannot be clearly distinguished from the lateral planes into which it merges (Fig. 3 d, e, h, i).

The anterior plane is directed downward and forward to about the level of the third or fourth rib; from this point, the forward inclination is less marked, but it continues downward to about the level of the lower end of the gladiolus.

The inclination of the plane may then change to slightly downward and backward; or it may continue the same or even slightly increase its forward direction, down to about the level of the ninth costal cartilage where it joins the costal margin, and then decrease gradually to the neighborhood of the umbilicus, depending on the volume and amount of distention of the underlying viscera.

From the umbilicus or perhaps above this point, it inclines backward and downward more or less rapidly, depending on the volume and amount of distention of the underlying viscera.

As has already been said, the square appearance of the upper portion of the trunk is due to its connection with the upper extremities by the pectoral muscles and the scapulæ, which form bridges anteriorly and posteriorly, these bridges concealing from view the upper portions of the trunk planes which are now visible (Fig. 3; Fig. 2 g, h).

The posterior plane (prone position) broadens from above downward until it reaches its maximum, at about the level of the apex of the twelfth rib; its breadth then decreases slightly to the neighborhood of the crest of the ilium. More and more, from above downward, in the prone position, the broadening of this plane is due to the ribs anterior to the posterior angle entering into this plane (Fig. 4 b, c, e).

TABLE I.—HEIGHTS OF THE THREE DIVISIONS OF THE TRUNK (TABLE II, a) (ARRANGED IN THE ORDER OF VERTEX HEIGHTS FROM THE HIGHEST DOWNWARD)

Cases at term											
Case	9-XV	9-VII	9-IX	9-XII	9-IV	9-XXII	9-XXV	0-XIII	9-VI	0-XXVII	9-XXVI
Weight (gm.)	5150	3865	2850	2775	....	2863	2400	2125	1850	2050	1700
Vertex height (mm.)	570	530	514	513	494	484	483	478	451	448	436
Division 1	55	57	44	44	58	50	45	47	50	46	34
Division 2	56	41	39	30	....	33	40	30	....	39	38
Division 3	88	81	80	91	....	83	73	80	....	65	60
Division 3 may be subdivided into two parts—(a) From the level of the ninth costal cartilage to the umbilicus; and (b) From the umbilicus to the symphysis:—											
(a)	35	31	36	43	..	30	30	37	....	19	28
(b)	53	50	44	48	45	53	43	43	41	46	32

Fetal cases					Av. in 3 cases at 6 mos.		
Case	7-XVIII	6-XIV	6-XX	6-XIX		5-XI	4-XVII
Weight (gm.)	1680	545	950	585	693.3	...	...
Vertex height (mm.)	448	380	360	318	352.6	274	172
Division 1	35	35	32	29	32	23	15
Division 2	37	24	29	29	27.3	19	14
Division 3	74	41	52	48	47	45	24
(a)	45	21	26	15	20.6	18	13
(b)	29	20	26	33	26.3	27	11

The posterior plane is marked in the center by the spinous processes of the vertebræ. On each side is a groove between the spinous and transverse processes; this groove is broader above, narrowing downward, and terminating in a point just above the posterior inferior spine of the ilium. A second groove is seen on each side, broader and shallower than the more median one, lying between the transverse processes of the vertebræ and the posterior angles of the ribs, these latter marking the outer boundary of the posterior plane in its upper part. These grooves are filled in and covered over by the muscles and the broad aponeuroses of the trunk (Fig. 4).

The lateral planes (supine position) at first extend forward from about the posterior angles of the ribs to about the junction of the ribs with the sternal cartilages (Fig. 4 c). In their upper portion these planes are flattened; from about the sixth rib downward they begin to round out laterally down to the crest of the ilium which is more or less overlapped by the soft tissues. This rounding out obscures the boundaries of the planes and leads to a gradual merging of the lateral with the anterior and posterior planes (Fig. 3 d, e, h, i; Fig. 2 i).

Posteriorly (prone position), the change is made very gradually; so that while at the third rib the lateral plane ends at the posterior angle of the rib, from there downward more and more of the rib gradually enters into the posterior plane, the maximum being from about the ninth rib downward (Fig. 4 c).

The broader the anterior and posterior planes, the shallower relatively is the lateral plane, and vice versa. So in passing from above downward, in both supine and prone positions, the lateral planes decrease in extent while the anterior and posterior planes increase (Figs. 3 and 4). The reverse is seen in the lateral position.

The lateral planes are directed obliquely downward and outward to the region of the greatest transverse diameter; they are then directed obliquely downward and more or less inward to the trunk-thigh lateral angle (Fig. 3 a to e; Fig. 4 a to c).

Three spontaneous divisions of the trunk: their dimensions (heights and diameters) and their related viscera. In looking at the child at term, in the supine position, three general divisions of the trunk suggest themselves (Fig. 3).

Division 1—the thorax down to about the level of the lower end of the gladiolus. This division increases in volume from above downward in correspondence with its contents—the œsophagus, trachea, and bronchi, thymus, great vessels, heart, and lungs, the last increasing notably in volume from above downward. And it is to be noted that the diaphragm, the liver, and the fundus of the stomach tend to project upward into the lower part of this division. It is most important to note that the lungs lie principally in relation with the posterior and lateral planes, and the heart, great vessels, and thymus with the anterior plane. It is also important to note that most of the scapula, the head of the humerus, and the shoulder joint lie in the lateral plane (Figs. 3, 4; Fig. 2 g, h).

This division is always wedge-shaped (truncated, quadrilateral pyramid) the smaller end directed upward. There

TABLE II, a.—CASES AT TERM. TRUNK MEASUREMENTS: VERTEX HEIGHTS AND FRACTIONAL TRUNK HEIGHTS, ANTEROPOSTERIOR AND TRANSVERSE DIAMETERS; GIRTHS. SUPINE POSITION; HEAD EXTENDED SO THAT THE FACE LIES IN THE FRONTAL PLANE; LOWER EXTREMITIES IN SPONTANEOUS FLEXION, ABDUCTION, AND OUTWARD ROTATION. COMPARE WITH FIGURE 3, a, c, f

Cases at term											
Case	9-XV	9-VII	9-IX	9-XII	9-IV	9-XXII	9-XXV	0-XIII	9-VI	0-XXVII	9-XXVI
Weight (gm.)	5150	3865	2850	2775	....	2863	2400	2125	1850	2050	1700
Heights (mm.)											
Vertex	570	530	514	513	494	484	483	478	451	448	436
Sternal notch	426	394	371	357	364	355	342	347	325	322	304
Gladiolus	371	337	327	313	306	305	297	300	275	276	270
Ninth costal cartilage	315	296	288	283	...	272	257	270	...	237	232
Umbilicus	280	265	252	240	235	242	227	233	205	218	204
Iliac crest (midaxial)	278	251	257	236	235	224	226	228	205	212	206
Symphysis pubis	227	215	208	192	190	189	184	190	164	172	172
Trunk diam. (mm.)											
Level sternal notch											
Anteroposterior	63	57	48	47	56	62	64	49	40	51	52
Shoulders											
Transverse	180	127	106	153	128	135	137	123	112	120	121
Third space											
Anteroposterior	84	76	70	72	72	78	76	68	60	66	64
Transverse	118	109	94	92	92	87	75	82	84	80	71
Gladiolus											
Anteroposterior	94	81	79	76	88	78	80	72	67	67	66
Transverse	122	126	103	99	108	94	90	96	89	85	85
Ninth rib (midaxial)											
Anteroposterior	92	80	80	73	..	80	75	68	..	66	65
Transverse	132	131	107	106	112	102	106	101	95	91	97
Ninth costal cartilage											
Anteroposterior	90	73	73	70	89	81	73	66	67	65	62
Transverse	131	134	113	110	112	104	109	102	103	94	101
Umbilicus											
Anteroposterior	88	66	64	48	73	76	67	57	54	65	56
Transverse	125	...	97	97	...	98	104	84	108	93	92
Iliac crests (midaxial)											
Anteroposterior	86	...	...	...	...	75	65	....	....	65	53
Transverse	123	112	105	95	100	99	104	84	73	90	92
Width subcostal angle at ninth costal cartilage	128	122	103	99	104	89	101	83	....	90	88
Girths (mm.)											
Gladiolus	370	360	314	292	329	301	284	274	....	255	253
Ninth rib (midaxial)	383	363	320	302	332	302	295	284	298	264	271
Ninth costal cartilage	373	350	315	300	336	299	287	276	302	260	271
Umbilicus	349	322	290	257	286	277	272	232	268	235	247

In estimating the vertex heights given in Table II, a, the measurements were taken from the level of the highest point of the vertex to the level of the heels. Two sources of variation are thus present: (1) the highest point of the vertex may be changed by the modeling undergone in the birth canal; and (2) the length of the lower extremities will vary according to the degree of extension, adduction, and forward rotation of the thigh and of extension of the knees. The measurements given in Table II, a, were taken by bringing the heels together and straightening the lower extremities within the degree of spontaneous resistance encountered. Where the contractions of one lower extremity were greater than in the other, the height was taken from the lowermost heel. In 8 cases at term and in 5 fetal cases, the differences in heel-vertex heights between that measured in spontaneous position of flexion, abduction, and outward rotation of the lower extremities and that measured after the heels were brought together and the lower extremities extended, adducted, and rotated inward within the limits of the resistance encountered, varied from 5 to 27 millimeters in the former group, and from 7 to 40 millimeters in the latter. In 6 of the former group and in 3 of the latter the variation was equal for both extremities; while in 2 of the former group and in 2 of the latter, the variation in the two extremities was unequal. In all of these 4 unequal cases, the difference was less in the right extremity, showing that the contractions of the deep fibrous tissues were slightly firmer on the right side, the difference varying from 2 to 4 millimeters at term and from 1 to 5 millimeters in the fetal cases.

In an attempt to exclude the surface irregularities, the fractional trunk heights in the supine position were taken along a horizontal line from one level to the next. In this endeavor to reduce errors of measurement to the lowest point a calipers was devised by the writer and developed according to her plans by G. F. Tiemann Company, New York, in 1904 (Fig. 5).

The anteroposterior diameters here shown as taken in the supine position are measured along a vertical line from the horizontal plane upon which the subject rests, making a varying slight overestimate about the level of the umbilicus and below, due to the varying ventrad elevation of the lumbosacral anterior convexity (Fig. 8, d l). It was not possible without distortion to place the lower point of the calipers next to the spine of the child so it was placed under the board upon which the spine rested. This board was 1 centimeter thick and the point of the calipers was curved upward for that distance and the scale so adjusted, hence the reading of the calipers would be as from the upper surface of the board.

is little variation in the form of this division, such variation as occurs being due to the fact that the upper end is larger or smaller in proportion to the lower end. In the undissected child, owing to the presence of the shoulder girdle, this division appears more square above (Fig. 3 d, e).

Viewed laterally, the anterior outline curves forward and downward from the sternal notch; this curve reaches a maximum at about the third or fourth rib, and this maximum tends to be maintained to the lower end of the division, though it may slightly increase (Fig. 3 f to j).

Division 2—from about the level of the lower end of the gladiolus to about the level of the ninth costal cartilage where it joins the costal margin. The shape of this division

TABLE II, b.—FETAL CASES. TRUNK MEASUREMENTS: VERTEX HEIGHTS AND FRACTIONAL TRUNK HEIGHTS; ANTEROPOSTERIOR AND TRANSVERSE DIAMETERS; GIRTHS

Fetal Cases					Av. in 3 cases at 6 mos.		
Case	7-XVIII	6-XIV	6-XX	6-XIX		5-XI	4-XVII
Weight (gm.)	1680	545	950	585	693.3	...	50
Heights (mm.)							
Vertex	450	380	360	318	352.6	274	172
Sternal notch	324	222	255	227	234.6	190	112
Gladiolus	289	187	223	198	202.6	167	97
Ninth costal cartilage	252	163	194	169	175.3	148	83
Umbilicus	217	142	168	154	154.6	130	70
Iliac crests (midaxial)	218	141	162	144	149	124	..
Symphysis pubis	178	122	142	121	128.3	103	59
Trunk diameter (mm.)							
Level sternal notch							
Anteroposterior	52	36	39	27	34	27	..
Shoulders							
Transverse	113	72	94	82	82.6	45	41
Third space							
Anteroposterior	63	45	49	41	45	30	
Transverse	72	47	62	54	54.3	45	
Gladiolus							
Anteroposterior	68	47	51	43	47	43	
Transverse	84	56	72	61	63	51	
Ninth rib (midaxial)							
Anteroposterior	68	45	52	42	46.3	47	
Transverse	94	57	81	66	68	57	
Ninth costal cartilage							
Anteroposterior	65	42	51	38	43.6	46	
Transverse	91	56	83	67	68.6	58	
Umbilicus							
Anteroposterior	58	34	43	34	37	45	
Transverse	82	48	75	56	59.6	45	
Iliac crests (midaxial)							
Anteroposterior	58	34	43	33	36.6	38	
Transverse	82	49	69	53	57	45	
Width subcostal angle at ninth costal cartilage	82	42	79	61	60.6	50	
Girths (mm.)							
Gladiolus	255	168	215	176	186.3	150	
Ninth rib (midaxial)	260	169	222	179	190	153	
Ninth costal cartilage	252	159	219	175	184.3	152	
Umbilicus	225	142	205	164	170.3	132	

corresponds with the conjoined shape of the viscera which it contains; and its increase and diminution correspond with the increase and diminution in volume of these viscera—the bases of the lungs, the diaphragm, the right and the left lobes of the liver, the stomach, spleen, pancreas, duodenum, jejuno-ileum, transverse colon, splenic flexure, and upper part of the descending colon; probably the adrenals, and perhaps the upper portion of the left kidney (Fig. 3 a to e).

This division is predominantly ellipsoidal, swelling out laterally, in the midaxillary line, from the sixth to the tenth ribs, the maximum being from the seventh to the ninth or tenth ribs. There is also a more or less marked anterior rounding which having begun in division 1 at about the level of the third or fourth rib, continues downward in this division to about the level of the ninth costal cartilage (Fig. 3 f to j). There is moderate variation in the form of this division, depending on variations in the size of the liver, and in the volume and amount of distention of the stomach and intestines.

Division 3—from about the level of the ninth costal cartilage at the costal margin to the suprapubic groove in front, and to a little below the crest of the ilium laterally. The shape of this division corresponds with the size and volume of its contained viscera—jejuno-ileum; ascending colon, cæcum; lower descending colon; sigmoid colon; perhaps sometimes the adrenals; usually the greater portions of the kidneys; the bladder; fundus uteri and ovaries; and perhaps redundant transverse, ascending, or descending colons (Fig. 3 a to e; Fig. 4 a to c; Fig. 2 g, h).

This division is predominantly a section of an ovoid, but at the sides it always tends more or less to overhang the crest of the ilium. There is a fair amount of variation in the form of this division, making toward a square or rectangular effect, depending upon the volume and amount of distention of the intestines, particularly the sigmoid colon, and also upon the amount of subcutaneous adipose tissue. It rounds out anteriorly, rather than laterally, any redundancy of its contents tending to travel forward rather than laterally or backward (Fig. 3 f to j). However, after a certain anterior limit is reached, it then rounds out laterally, becoming more square or rectangular and overhanging its lower boundaries.

Predominantly, then, the trunk appears to consist of a truncated, quadrilateral pyramid (division 1) blending at its base with a section of a more or less flattened ovoid (divisions 2 and 3), the latter tapering downward to the top of the symphysis pubis in front (suprapubic groove), and to a little below the crests of the ilia laterally. Occasionally, the ovoid

TABLE II, c.—CASES AT TERM

Fractional trunk heights from the symphysis as unity Case	9-XV	9-VII	9-IX	9-XII	9-IV	9-XXII	9-XXV	0-XIII	9-VI	0-XXVII	9-XXVI	Average
Vertex	343	315	306	321	304	295	299	288	287	276	264	299.8
Sternal notch	199	179	163	165	174	166	158	157	161	150	132	164.0
Gladiolus	144	122	119	121	116	116	113	110	111	104	98	115.8
Ninth costal cartilage	88	81	80	91	...	83	93	80	...	65	60	80.1 (av. of 9 cases)
Umbilicus	53	50	44	48	45	53	43	43	41	46	32	45.2
Symphysis pubis	0	0	0	0	0	0	0	0	0	0	0	0
Fractional trunk heights from one level to the next above												
Sternal notch to vertex	144	136	143	156	130	129	141	131	126	126	132	135.8
Gladiolus to sternal notch	55	57	44	44	58	50	45	47	50	46	34	48.1
Ninth costal cartilage to gladiolus	56	41	39	30	...	33	20	30	...	39	38	36.2 (av. of 9 cases)
Umbilicus to ninth costal cartilage	35	31	36	43	...	30	50	37	...	19	28	34.3 (av. of 9 cases)
Symphysis to umbilicus	53	50	44	48	45	53	43	43	41	46	32	45.2

narrows less gradually, resulting in a more square or rectangular appearance.

Prone position—Posteriorly, the outline and boundaries of division 1 are obscured by the scapulæ and their connecting muscles. When these are dissected away, the truncated, quadrilateral, pyramidal shape is seen. The lateral outlines of division 2 bulge further outward, from the yielding of the lateral walls to the pressure of the anterior and posterior walls. The anterior walls are flattened by the greater resistance of the table on which the child rests, and the posterior walls fall toward the table, on account of their own weight and the weight of the viscera. Division 3 shows a similar lateral bulging, but predominantly the downward tapering already indicated. When the lower divisions are square or rectangular, the lateral bulging is more marked (Fig. 4 a to c).

Heights of the three divisions of the trunk. Considerable individual variation exists in the heights of the divisions of the trunk (Table I) as calculated from the fractional trunk heights (Tables II, a, II, b, II, c, II, d), these variations being roughly but not exactly related to the vertex height of the child, and being similar throughout prenatal life from the fourth month onward.

All the measurements in Tables I to III except the vertex heights are taken with the head extended so that the face lies in the frontal plane, and with the lower extremities in spontaneous flexion, abduction, and outward rotation.

The height of division 1 varies in 11 cases at term from 34 to 58 millimeters, and in 6 fetal cases from 15 to 35 millimeters; division 2 varies from 30 to 56 millimeters and from 14 to 37 millimeters, in the two groups, respectively; while division 3 varies from 60 to 91 millimeters and from 24 to 74 millimeters, respectively.

Division 3 always predominates in height; division 2 is most often shorter than division 1 (from 5 to 17 millimeters at term; from 1 to 4 millimeters in the fetal cases), (7 of 9 cases at term, 4 of 6 fetal cases), occasionally it is the same or a trifle greater (2 of 9 cases at term, 2 of 6 fetal cases).

Diameters of the three divisions of the trunk. A study of Tables II, a, and II, b, shows that as far back as the sixth month, the *anteroposterior* (dorsoventrad) diameter of the trunk proper is on the whole shortest at the level of the umbilicus, or sometimes at the level of the crest of the ilium in the midaxillary line (the umbilicus is sometimes on the same level as the crest of the ilium, sometimes it is cephalad to this level). It is absolutely the shortest in all except 2 of the 11 cases at term and 1 fetal case at the fifth month.

In these 3 cases (9-XV, 9-IV, 5-XI), the shortest anteroposterior diameter is at the level of the third space (midaxial) but the difference is trivial and the diameter at the umbilicus (or crest of the ilium) is the next in length in the 2 cases at term; in 5-XI, the next in length is at the level of the gladiolus, the diameter at the umbilicus coming third.

With the 3 exceptions noted, the second shortest anteroposterior diameter of the trunk proper is at the level of the third space, midaxial (about the level of the apex of the axilla). From this level, the anteroposterior diameter tends to increase in depth rather steadily toward the level of the gladiolus; it then remains about the same, or slightly decreases, to the level of the ninth costal cartilage (costal margin), and then decreases more rapidly to its minimum depth at the level of the umbilicus (or crest of the ilium).

In 7 of the 11 cases at term and in 2 of the 5 fetal cases (0-XIII, 0-XXVII, 9-VII, 9-XII, 9-XV, 9-XXV, 9-XXVI; 6-XIV, 6-XIX), the deepest anteroposterior diameter is at the level of the gladiolus; in 1 at term and 2 fetal cases it is at the level of the ninth rib (9-IX, 6-XX, 5-XI); in 2 at term it is at the level of the ninth costal cartilage (9-IV, 9-XXII); in 1 at term it is from the level of the gladiolus to that of the ninth costal cartilage (9-VI); and in 1 fetal case it is from the level of the gladiolus to that of the ninth rib (7-XVIII).

TABLE II, d.—FETAL CASES

Fractional trunk heights from the symphysis as unity							
Case	7-XVIII	6-XIV	6-XX	6-XIX	Av. in 3 cases at 6 mos.	5-XI	4-XVII
Vertex	270	258	218	197	224.3	171	113
Sternal notch	146	100	113	106	106.3	87	53
Gladiolus	111	65	81	77	74.3	64	38
Ninth costal cartilage	74	41	52	48	47.0	45	24
Umbilicus	29	20	26	33	26.3	27	11
Symphysis	0	0	0	0	0	0	0
Fractional trunk heights from one level to the next above							
Sternal notch to vertex	124	158	105	91	118.0	84	60
Gladiolus to sternal notch	35	35	32	29	32.0	23	15
Ninth costal cartilage to gladiolus	37	24	29	29	27.3	19	14
Umbilicus to ninth costal cartilage	45	21	26	15	20.6	18	13
Symphysis to umbilicus	29	20	26	33	26.3	27	11

On the other hand, in every case, the *transverse* diameter is shortest at the level of the third space, midaxial. From this level it increases steadily down to the level of the ninth costal cartilage (costal margin), and then decreases rather gradually but not to a very marked extent to the level of the umbilicus, or perhaps to that of the crest of the ilium, midaxial—the diameter at the latter level being the same as at the umbilicus or varying a trifle more or less.

In the 11 cases at term and in the 5 fetal cases, the average increase in the transverse diameter from the level of the third space, midaxial, to that of the ninth costal cartilage (costal margin) is 21 and 15.5 millimeters, respectively; and in 10 of the 11 cases at term and in the 5 fetal cases, the average decrease from the level of the ninth costal cartilage to that of the umbilicus is 11 and 9 millimeters, respectively—the eleventh case at term showing an increase of 5 millimeters.

Thus, both anteroposterior and transverse diameters of the trunk increase from the neighborhood of the level of the third space, midaxial, to that of the gladiolus, the anteroposterior then ceasing to increase, the transverse continuing to increase to the neighborhood of the level of the ninth costal cartilage; from this point downward both decrease, the anteroposterior more rapidly and definitely.

Indices of the transverse planes of the trunk. The index of a given trunk plane (Table III) is obtained by multiplying the anteroposterior diameter by 100 and dividing the product by the transverse diameter:

$$\frac{\text{Anteroposterior diameter} \times 100}{\text{Transverse diameter}}$$

The more nearly the two diameters approach each other in length, the more nearly the index of the trunk plane will approach 100. The less the transverse diameter predominates over the anteroposterior diameter, the higher the index; the more the transverse diameter predominates over the anteroposterior diameter, the lower the index.

A study of Table III shows that in all the prenatal cases as far back as the sixth month, the index tends to be highest at the level of the third space, midaxial (7 of 11 cases at term; 4 fetal cases); and that thence downward it steadily diminishes, reaching its minimum at the level of the crest of the ilium, midaxial, or of the umbilicus or, occasionally, of the ninth costal cartilage.

In 4 of the 11 cases at term, there is a slight rise in the index as the gladiolus is reached, the steady decrease beginning at this latter level (9-IV, 9-VI, 9-IX, 9-XV). In these cases, although the transverse diameter follows the rule by increasing, there is a disproportionate increase in the anteroposterior diameter, hence the higher index. In the case at the fifth month, the usual diminution in indices occurs until the umbilicus is reached, there the transverse diameter narrows to the depth of the anteroposterior diameter, giving an increased index (100).

Relation between diameters and indices of transverse trunk planes. Remembering that the index of a trunk plane becomes lower in proportion as the transverse diameter predominates over the anteroposterior diameter, one must be on guard and recognize that the trunk plane having the lowest index does not necessarily correspond with the trunk plane having the longest transverse or the shortest anteroposterior diameter. The diameters express the absolute distances; the indices express the proportional relation of these diameters; hence, a trunk plane having a longer transverse diameter may have the latter so modified by a deeper anteroposterior diameter that its index may be raised. Consequently, Tables II and III do not contradict each other, but the predominating

TABLE III.—INDICES OF THE TRANSVERSE PLANES OF THE TRUNK ARRANGED IN THE ORDER OF VERTEX HEIGHTS AS IN TABLE I

Cases at term											Av.
Case	9-XV	9-VII	9-IX	9-XII	9-IV	9-XXII	9-XXV	0-XIII	9-VI	0-XXVII	9-XXVI	Index
Third space (midaxial)	71.1	69.7	74.4	78.2	78.2	89.6	90.6	82.9	71.4	82.5	90.1	79.8
Gladiolus	77.0	64.2	76.6	76.7	81.4	82.9	80.0	75.0	80.8	78.8	77.6	77.3
Ninth rib (midaxial)	69.6	61.0	74.7	68.8	78.5	78.4	63.2	67.3	73.6	72.5	67.0	70.4
Ninth costal cartilage	68.7	54.4	64.6	63.6	78.7	77.8	59.6	64.7	65.0	69.1	61.3	66.1
Umbilicus	70.4	56.8	65.9	49.4	73.0	77.5	56.7	67.8	50.0	69.8	60.8	63.4
Iliac crests (midaxial)	68.2	50.0	60.9	50.5	73.0	75.7	54.8	67.8	73.9	72.2	60.8	64.3

Fetal cases					Av. in 3 cases	
Case	7-XVIII	6-XIV	6-XX	6-XIX	at 6 mos.	5-XI
Third space (midaxial)	87.5	95.7	79.0	75.9	83.5	86.6
Gladiolus	80.9	83.9	70.8	70.4	75.0	84.3
Ninth rib (midaxial)	72.3	78.9	64.1	63.6	68.8	82.4
Ninth costal cartilage	71.4	75.0	61.4	56.7	64.3	79.3
Umbilicus	70.7	70.8	57.3	60.7	62.9	100.0
Iliac crests (midaxial)	70.7	69.3	62.3	62.2	64.6	84.4

variation in the length of the transverse diameters of the trunk planes does not exactly correspond with the predominating variation in the indices of these trunk planes.

Thus in 9-XV, the longest transverse diameter is at the level of the ninth rib or the ninth costal cartilage, and the shortest anteroposterior diameter is at the level of the third space or of the crest of the ilium, but the lowest index is at the level of the crest of the ilium or of the ninth costal cartilage; and so on.

Trunk girths. A study of Tables II, a, and II, b, shows that throughout prenatal life as far back as the sixth month, the trunk girth tends to be greatest at the level of the ninth rib, midaxial, and is in all cases smallest at the level of the umbilicus; that at term the greatest girth sometimes occurs at the level of the ninth costal cartilage; and that while the girths at the level of the gladiolus and of the ninth costal cartilage tend to approach each other, the latter is generally the larger.

On the whole, then, the girth of the trunk tends to increase from the level of the gladiolus to that of the ninth rib, midaxial; it then tends to decrease slightly to the level of the ninth costal cartilage, but at term this decrease may not occur, or in some cases there may even be a slight increase; while from this level downward the girth in all cases decreases more rapidly to the level of the umbilicus (or iliac crests?).

THE LOWER EXTREMITIES

The spontaneous position of the lower extremities at term. In the supine position, with the lower extremities in the attitude which they assume spontaneously (Figs. 2, 3, 4), the thighs appear to spring from the sides of the lower part of the trunk (pelvis), an angle (the trunk-thigh lateral angle) being formed between the anterior or anterolateral surface of the thigh (as far down as the knee) and the anterolateral or lateral surface of the trunk. The two arms of the angle appear to join in the neighborhood of the crest of the ilium (most often about a third or a half downward of the space between the crest of the ilium and the top of the trochanter), at the "waist" line which appears to form the lower boundary of the trunk. The pelvic soft tissues below the apex of the angle appear continuous with those of the thigh, the surface being broken only by the fading suprapubic and groin grooves.

This peculiar appearance is due to the fact that the thigh assumes spontaneously a position of greater or less flexion, abduction and outward rotation, so that the outer surface of the great trochanter is directed more or less posteriorly, and the patella looks forward and outward. The buttocks are broad and the thigh is large and bulges laterally outside of the trochanter (Fig. 4). The angle of flexion between the trunk and the thigh is usually greater than a right angle (125 degrees; 140 degrees; etc.). The thigh is abducted from the median line in varying degrees (45 degrees, 80 degrees, etc.), the abduction being modified by the degree of the accompanying flexion and outward rotation. Occasionally it is such that the outer surface of the thigh lies flat on the table but usually this outer surface makes an angle of 10 degrees or more with the table.

The leg is flexed on the thigh at varying angles, often in the neighborhood of 90 degrees; sometimes less, sometimes more (30, 55, 140 degrees, etc.). The foot is flexed on the leg at an angle often in the neighbor-

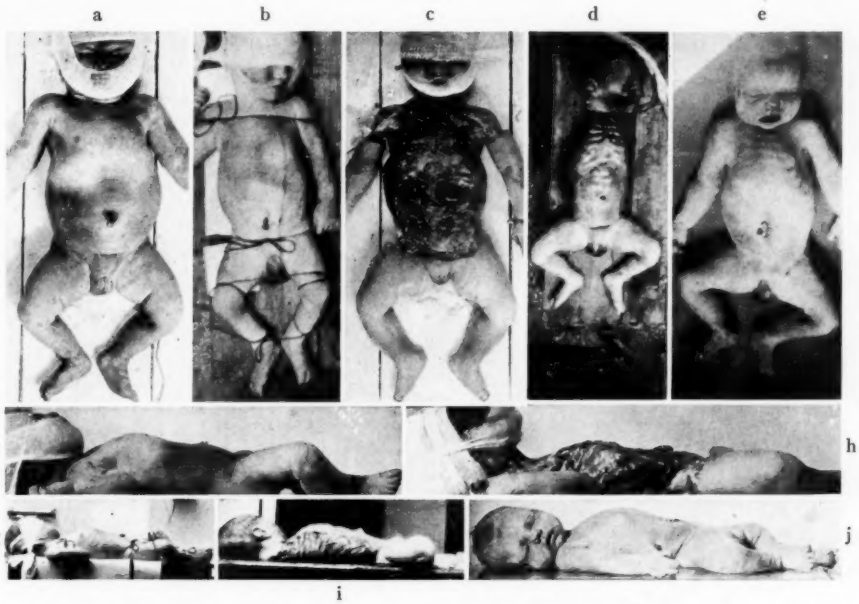


Fig. 3. a, b, Shape of the trunk at term, in the supine position; anterior view, seen from above (9-LXIX, 9-XLVI). c, Another subject (9-LXVIII); same position and view as in a and b, with the skin and superficial fascia removed from the trunk, shoulders, and neck. d, Another subject (9-XXXIX); similar to 3 c but with the shoulder girdle and some of the external muscles removed. e, Another subject (9-LIX); showing outline of 3 d with the shoulder girdle in place. f, Same subject as in 3 a (9-LXIX) but profile view; front and back profiles of the trunk in the supine position. g, Same subject as in 3 b, same view as in 3 f. h, Same subject as in 3 c; profile view. i, Same subject as in 3 d; profile view. j, Same subject as in 3 e (9-LIX); profile view.

hood of 90 degrees, sometimes less (45, 60 degrees, etc.), sometimes more.

The leg and foot follow the thigh in its outward rotation, so that they tend to rest on their outer surfaces; the calf is broad and the crest of the tibia looks forward and outward, and more or less downward, the feet lying on the outer border or even partly on the dorsum. The flexion of the knees carries the feet toward the middle line of the body, the soles looking more or less mediad. The heels approximate and the feet diverge downward and outward, sometimes also forward, from the heel. Sometimes, the two soles approximate throughout their length. Sometimes, the feet lie one crossed above the other, one sole as if clasping the opposite tibia.

This position of flexion, abduction, and outward rotation which the lower extremities spontaneously assume, is the remnant of older biologic positions which are now, and which have been throughout prenatal life, in transition toward the human type postnatal position of extension, adduction, and inward rotation so that the patellæ and feet look forward (Compare with Fig. 2 c and d).

The feet tend toward supination, the soles looking a little upward, sometimes markedly so. The heels are small and pointed and covered with a fat cushion; the ball of the foot is broad; and unless obscured by fat cushions the longitudinal and transverse (anterior) arches are definite. The instep is broad, but the ball and toes are still broader. The toes lie side by side, not encroaching upon each other, the great toe tending to be more markedly separate from its adjacent neighbor (Fig. 2 g to i; Fig. 3 j ; Fig. 4 e). The toes are usually slightly flexed, especially the middle and distal phalanges. Sometimes to flexion of the middle and terminal phalanges is added extension of the first or proximal.

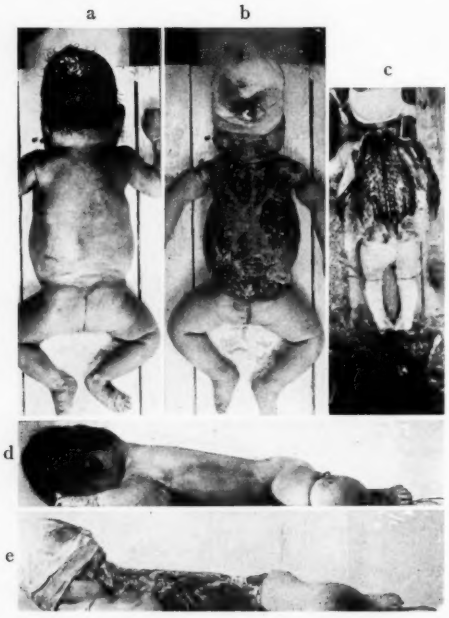


Fig. 4. a, Same subject as in Figure 3 a; in the prone position, posterior view, seen from above. 4 b, Same subject as in Figure 3 c; same view as in 4 a with the skin and superficial fascia removed from the trunk, shoulders, and neck. Note the removal of the pyramidal mass of fat (apex inward) from the left Petit's triangle and the consequent narrowing of the lower pole of the trunk (loin) on that side. The broadening of the right loin from this factor is shown by the replacement of the fatty plug on that side. c, Same subject as in Figure 3 d; same view as 4 b with the shoulder girdle detached posteriorly and the external muscles removed. Note the narrowness of the posterior plane and the forward inclination of the flattened lateral planes in division 1, also the decreasing breadth of this division from below upward, all these conditions favoring upward and forward sliding of the scapulæ. d, Same subject as in 4 a but profile view; front and back profiles of the trunk in the prone position. e, Same subject as in 4 b; profile view.

Fig. 5 Calipers for measuring fractional trunk heights and trunk diameters along a straight line, devised by the writer, and developed by G. F. Tiemann Co., New York, in 1904.

The degree of supination and the presence of the longitudinal arch are best demonstrated by leaving the lower extremities on the table and moving toward approximating the outer borders of the soles of the feet as they lie—a position which is sometimes assumed spontaneously (Fig. 2 b, g).

The longitudinal arch is reflected upon the dorsum of the foot which toward the inner half is elevated proportionately, the dorsum falling toward the outer half as the arch disappears and the sole descends to the plane of the heel and forefoot.

When the anterior arch is marked, the first phalanges continue the distally declining oblique line of the dorsum of the foot and continue the line of the metatarsals, gradually moving toward the plantar flexion of the more distal phalanges (Fig. 2 h—left foot, i—both feet; Fig. 3 b—both feet, d—right foot, f—right foot, g—right foot). When the anterior arch is less marked, the distally declining oblique line of the dorsum of the foot is broken at the metatarsophalangeal junction by an angle opening dorsally, the first phalanges moving toward dorsal flexion with lowering of their proximal ends. The distal ends of these first phalanges thus project upward, and, the palmar flexion of the more distal phalanges continuing, the appearance of "claw" or "hammer" toes is thus produced (Fig. 2 b—left foot, g—both feet, h—right foot; Fig. 3 a—right foot). This variability suggests that the anterior arch is not definitely fixed at term and that it depends upon free

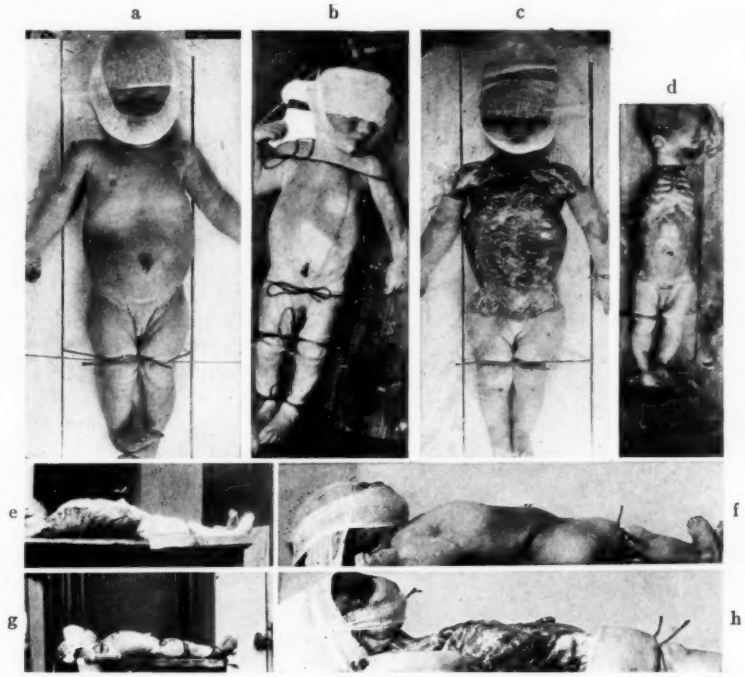


Fig. 6. a, Same subject as in Figure 3 a and same position but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward. Note the strong action toward adduction and supination of the feet due to extension of the thighs and knees. The thighs are tied in a slightly exaggerated inward rotation to counteract the strong pull of the deep fibrous tissues toward flexion, abduction, and outward rotation. Note the greater firmness of the contracted fibrous tissues in the right extremity, causing shortening of that extremity from persisting flexion at the hip and knee. b, Same subject as in Figure 3 b, and same position but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward, all of these changes being less complete than in 6 a. Note the beginning interference of the fore part of the feet with each other, both extremities being about the same length. c, Same subject as in Figure 3 c, and same position but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward. Note the narrowing of the trunk from side to side and the descent of the symphysis. d, Same subject as in Figure 3 d and same position but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward. Note the sharp flattening of the lateral planes as they pass backward from their junction with the anterior plane. e, Same subject as in Figure 3 i and same position but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward. Note the forward and downward rotation of the pelvis, the forward arching of the lumbosacral region (posterior abdominal wall), the forward projection of the anterior wall of the whole trunk, the upward and forward rotation of the thoracic cage, and the lengthening of the abdomen anteriorly. f, Same subject as in 6 a and same position but viewed in profile. Compare with Figure 3 f. The forward arching of the lumbosacral region is shown more clearly than in the preceding case. g, Same subject as in 6 b and same position but viewed in profile. Compare with Figure 3 g. The tying of the lower extremities has relaxed somewhat, allowing the firm fibrous tissues to draw the extremities toward their former outward rotation, as shown in the patellæ and feet. h, Same subject as in 6 c and same position but viewed in profile. Compare with Figure 3 h. As in the preceding case, the tying has relaxed somewhat and the continual action of the deep fibrous tissues has drawn the right lower extremity toward its former outward rotation, as shown in the position of the patella and foot.

plantar flexion of the metatarsophalangeal articulations and the preservation of the grasping powers of the whole forefoot (Fig. 2 i; compare with subhuman forms—Fig. 2 c, d, e, f).

The inner border of the foot forms a very obtuse angle opening inward (mediad) and a little forward at about the level of the scaphoid or a little anterior to this bone. The first metatarsal bone and the great toe form

Fig. 7. a, Same subject as in Figure 4 a and same position (prone viewed from above) but with the lower extremities extended, adducted, and rotated inward so that the patellæ look forward. b, Same subject as in Figure 4 b, and same position but with the lower extremities extended, adducted, and rotated inward, the latter more markedly than in 6 a. Note the narrowing of the deeper back of the whole trunk, especially of the loins. Note also the change in direction of the anus and the vulvar opening (perineum), now looking less downward and more backward, due to the forward and downward rotation of the pelvis. c, Same subject as in Figure 4 c, and same position, but with the lower extremities extended, adducted, and rotated inward, the latter less markedly than in 7 a. d, Same subject as in 7 a and same position but viewed in profile. Compare with Fig. 4 d. This view shows very clearly the forward and downward rotation of the pelvis and the increased anterior convexity of the lumbosacral region, and it makes plain the change in direction of the anus and perineum, as well as in the longitudinal axis of the pelvis. Note the diminished shortening of the right lower extremity over that seen in 7 a due to the forcible stretching of the deep fibrous tissues under prolonged confinement in the postnatal position. e, Same subject as in 7 b and same position but viewed in profile. Compare with Fig. 4 e. Note the marked anterior convexity in the cervicothoracic region due to hyperextension of the head and neck.

the anterior arm of this angle, this anterior arm extending forward and still farther mediad. The outer border of the foot forms a very obtuse angle opening outward at about the level of the cuboid. The fifth metatarsal bone and the fifth toe form the anterior arm of this angle, this anterior arm extending forward and still farther outward (Fig. 2 a, b, g; Fig. 3 f, g, j; Fig. 4 c, d. Compare with Fig. 2 c for a subhuman foot showing similar angles; d, e, f for a subhuman foot showing diminution or absence of these angles; and h, i for a human foot at term showing almost complete obliteration of the internal angle of the right foot under pronation).

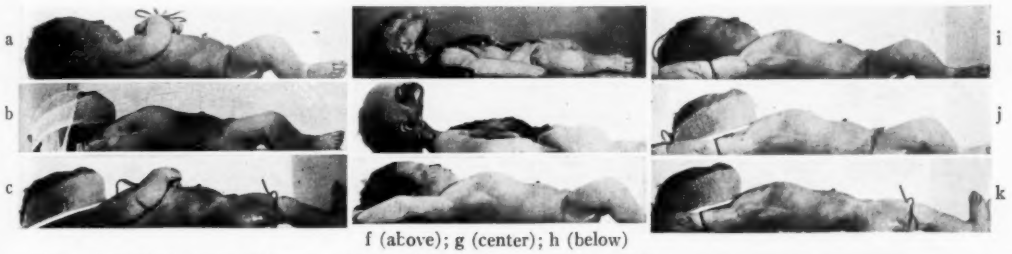
The femur is curved from without inward and from before backward, the convexity looking forward and outward and being on what becomes the anterior surface when the bone is rotated so that the patella looks forward, this surface now being directed forward and outward.

The bones of the leg are curved, concave inward and forward, the concavity being on what becomes the internal surface when the thigh is rotated so that the patella looks forward, this surface now being directed inward and forward, the curve being more marked in the tibia than in the fibula. This curved line continues downward to the sole where the heel tends to merge into the beginning of the arch, the line being broken only by the slight prominence of the internal malleolus.

In this position, if the leg is lifted from the table, the foot hangs loosely at the ankle and the weight of the foot causes it to sag toward the outside of the leg, causing the internal malleolus to bulge, and the foot tends to fall laterally toward a right angle with the leg, and the part forward of the ankle to droop lower than the heel.

Changes in the lower extremities and modifications of the body form occurring at term as the advanced postnatal position of the lower extremities is developed. If one attempts to place the flexed, abducted, and outwardly rotated lower extremities in the postnatal position of extension, adduction, and inward rotation so that the patellæ look forward, resistance is met. If this resistance is disregarded, it is found that the postnatal position can be attained only by compensatory changes in the pelvis, abdomen, spine, and thorax, as well as by direct changes in the lower extremities themselves (thigh, leg, and foot). Summarized, these changes may be grouped as follows (Figs. 6 and 7; compare with Figs. 3 and 4):

1. The trunk-thigh lateral angle increases toward practical disappearance and the lateral pelvic region becomes defined between the



f (above); g (center); h (below)

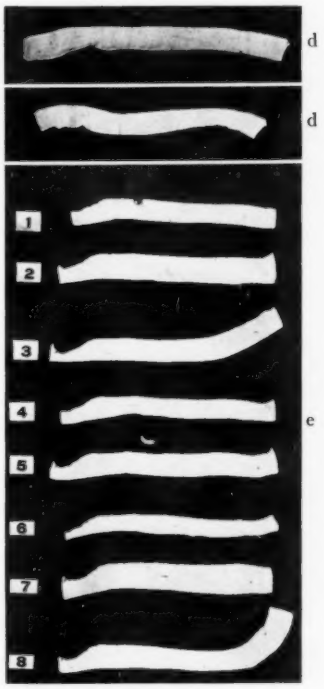
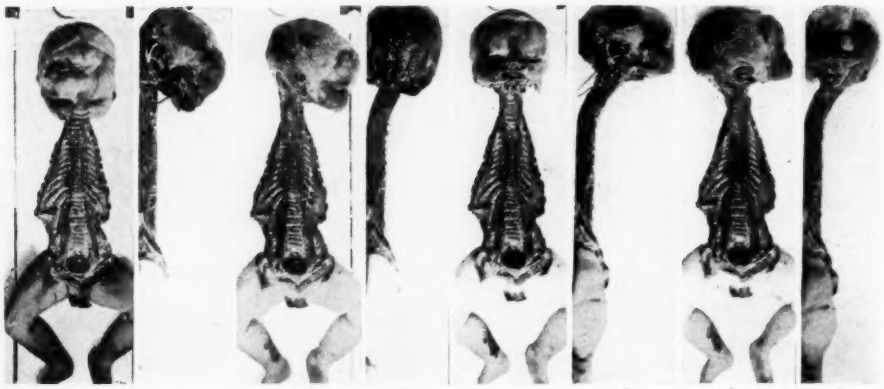


Fig. 8. The spinal curves at term. a, Same subject and same position as in Figure 3 f but with the head in spontaneous flexion, and with the arm drawn forward enough to show the apparent absence of anteroposterior spinal curves in the supine position at term. b, Same subject and same position as in 8 a but with the head held in extension so that the face is in the frontal plane, i.e., in a plane parallel with that upon which the trunk rests. c, Same subject and same position as in 8 b, but with the lower extremities extended, adducted, and rotated inward, and with the arm drawn forward as in 8 a. d, Posterior line of the spine in the undissected subject; supine position; viewed from the right. Note only the lower line of these two casts: *1*, plaster cast showing along its lower edge the posterior line of the spine and lower occiput in 8 b; *2*, plaster cast showing along its lower edge the posterior line of the spine and lower occiput in 8 c. e, Anterior line of the spine after removal of all the viscera: supine position; viewed from the left. Note only the upper line of all these casts: *1* to *6*, (9-LI); *7*, *8*, (9-LII). *1*, *7*, Plaster cast showing along its upper edge the anterior line of the spine when the head is flexed so that it rests on the lower part of the occipital protuberance (a trifle more flexion than in Figure 11 a; compare with Fig. 11 b). *2*, *6*, Head flexed so that the face lies in a plane which makes an angle of about 45 degrees with the horizontal plane upon which the trunk rests (Fig. 11 a). *3*, *8*, Head extended so that the face lies in the frontal plane, i.e., in a plane parallel to that upon which the trunk rests, a trifle more extension than in Figure 11 d. *4*, *5*, Same extended position of the head as in *3* but the occiput is allowed to seek its support (13 and 35 millimeters, respectively) below the horizontal plane upon which the trunk rests, till the articular base of the occiput is in line with the straight cervical spine, the latter resting on the same horizontal support as the trunk (Fig. 11 g, h, i). f, (9-LIII), g (9-LXIII), Development of a cervical anterior convex curve by both flexion and extension of the head when the backward and downward excursion of the occiput is restrained by its resting upon the same horizontal plane as that upon which the trunk rests. Upward and forward rotation of the thoracic cage upon a transverse axis, caused by raising the arms so that the humerus approaches the side of the head. Same subject as in 8 a. h, Same position as in a but with the arms raised to the side of the head without forcing extension of the elbow. i, Same as h but with the humerus tied in position and with the elbow tied in extension. j, Same as i, but with the head supported in extension so that the face lies in the frontal plane. k, Same as j but with the lower extremities held in extension, adduction, and inward rotation.

crest of the ilium and the trochanter; the outer surface of the great trochanter looks backward and outward instead of backward, and a depression forms behind it, while the buttocks narrow and fall. The whole trunk narrows from side to side (especially the loins) and appears to elongate. Modeling of the trunk, thighs, legs, and feet develops.

The anterior, internal, and external surfaces of the thighs become tense, and depressions appear in front of, behind, and below the trochanter, while a depressed longitudinal band of tension extends down the outer surface of the thigh toward the knee. The adductor region is thrown into oblique grooves running downward, inward, and backward. The tension in the thighs is conveyed over the patella and around it on both sides to the legs (more marked on the inner sides) which now describe a slight curve with the concavity mediad. There is added strong tension down the back of the thighs and legs to the heels.

The tension in the legs is conveyed over the dorsum and sides of the feet which now continue the curved line of the legs, and tend to



a b c d e f g h

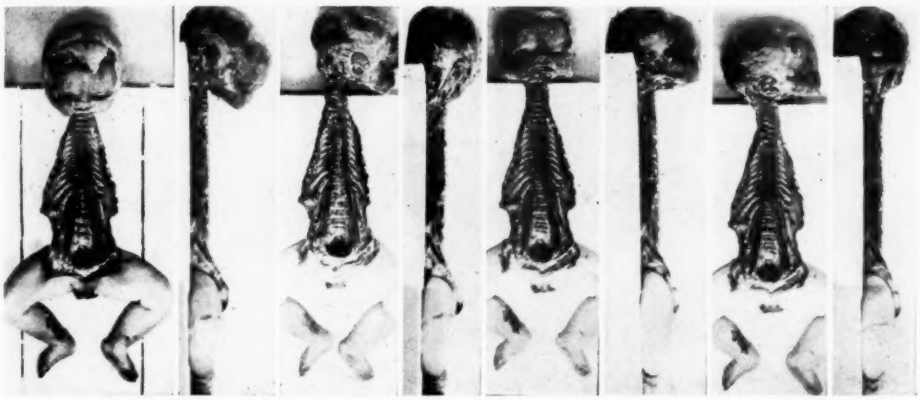
Fig. 9. The cervical curves (cont.). Same subject as in Figure 8 g. Lower extremities in spontaneous flexion, abduction, and outward rotation; occiput resting on the same plane as the trunk. All front views are taken from above; all profile views are taken from the right. a, Face forward; head flexed forward; front view. b, Same position but profile view, showing straight cervical spine with, perhaps, a short anterior concave curve of upper pole. c, Head flexed forward and rotated so that the face looks to the left; front view, showing lateral deviation of the cervical or cervicothoracic spine, with rotation of the vertebral bodies toward the line of the face. d, Same position as in c but profile view, showing added cervica or cervicothoracic lateral curvature. e, Face forward, head extended so that the face lies in the frontal plane; front view. f, Same position as in e; profile view, showing anterior convex curve of the cervical or cervicothoracic spine. g, Head extended as in e but rotated so that the face looks to the left; front view, showing added latera deviation of the cervical or cervicothoracic spine, with rotation of the vertebral bodies towards the line of the face. h, Same position as in g but taken so as to give a profile view showing added cervical or cervicothoracic lateral curvature.

overlap. The feet follow the curve of the tibia causing the front of the feet to approach, so that the first and second metatarsal bones may overlap, while the internal malleoli are still separated, the axis of the leg now falling toward the outer toes. The angle on the internal border of the foot becomes more rounded and its apex appears to move nearer to the ankle, owing to the inward rotation and supination of the foot. For the same reason the angle on the external border rounds so that this border may tend to continue the slight externally convex line of the leg (Fig. 2 i—the left foot; Fig. 6 a to f; Fig. 7 a, b).

If the leg is now lifted from the table the angle at the ankle between the leg and the foot is increased by the foot in front of the ankle falling downward, so that the sole lies in a plane inclined downward and forward. The feet swing flail-like on the leg but tend to turn as above.

2. The pelvis rotates forward and downward about a transverse axis (Fig. 6, compare with Fig. 3; Fig. 7, compare with Fig. 4); the ilia and upper part of the sacrum are carried forward and downward; the lower part of the sacrum is carried backward and upward; and the symphysis pubis descends. The fifth lumbar vertebra follows the upper sacrum and the ilia, and the other lumbar vertebræ and often the lower thoracic vertebræ are reluctantly dragged after the fifth, forming an anterior convex curve, deepest at the point of firmest union and greatest stress, and decreasing upward as the mobility of the vertebræ increases and as the stress decreases. The supine pelvis now rests on a lower portion of the posterior plane than when the thighs are in spontaneous flexion. For instance, resting upon the lower sacrum when the thighs are in spontaneous flexion, it would rest upon the junction of the sacrum and coccyx when the thighs are extended (Compare Fig. 12 b, d, f, h with Fig. 9 b, d, f, h).

3. This changed position of the lower extremities, the pelvis, and the lumbosacrothoracic spine causes a marked change in the abdomen and its viscera, and in the thoracic cage. The abdominal cavity is contracted from behind forward by the throwing forward of the lumbosacrothoracic and the upper iliac regions, and it appears narrowed from side to side especially in the region of the loins.



a b c d e g h

Fig. 10. The straight cervical spine, a to h. Same subject and same positions as in Figure 9, except that the occiput is unrestrained in both flexion and extension of the head, and is allowed to seek its normal positions dorsad to the straight cervical spine, coming to rest on a horizontal plane which is lower (dorsad) than that upon which the trunk rests but parallel to it. Note the absence of the cervical lateral curvature when the head is rotated to one or the other side, though the lateral deviation appears, but to a lessened extent.

The pelvis no longer looks like the upward expansion of the lower extremities, united with the trunk at the trunk-thigh lateral angle. It now appears like the lower portion of the trunk, of which latter the lower extremities appear to be direct downward continuations. It lies more obliquely between the trunk and the lower extremities, the latter now lying in a plane the long axis of which continues the long axis of the trunk. As a result of this changed position, the viscera no longer rest so completely upon the broader back and within the upper pelvis but are thrown forward and downward, causing increased stress on the anterior and anterolateral walls which are lengthened by the descent of the symphysis (Fig. 6, compare with Fig. 3), while the back appears shortened by the increased lumbosacral angulation (Fig. 7, compare with Fig. 4).

4. In proportion as the tension from the anterior convexity of the lumbosacral region extends upward into the thoracic region, the thoracic cage tends to be rotated upward and forward, again causing lengthening of the abdomen anteriorly.

These changes in body form cause some variations in the trunk measurements. Attempts were made to resolve these complex changes into their simpler elements, so note was made of the details observed when in its spontaneous position no change was made except to rotate the thigh inward, or to adduct it, or to extend it; or to extend the knee in the varying positions of the thigh.

Thus, inward rotation of the thigh can be accomplished as an isolated action when the thigh is left in its original flexion and abduction (b). But adduction of the thighs so that the knees approach each other and the patellæ look forward cannot be accomplished as an isolated action, this movement being always accompanied synchronously by inward (forward) rotation (c). The thighs can be adducted with a minimum of inward rotation if the knees are allowed to overlap, the flexion of the overlapping thigh being then increased.

Extension of the thigh on the pelvis can be accomplished in both the abducted (d) and adducted (e) positions, this action always being accompanied by less (d) or more (e) forward and downward rotation of the pelvis upon a transverse axis, and by a beginning extension of the leg at the knee—this latter movement extending to the foot, and in its most complete form causing inward rotation of the leg and foot, with supination and adduction and with overlapping of the fore part of the feet.

Extension of the leg on the thigh can be accomplished in both the abducted (a) and adducted (f) positions of the thigh, and in both positions the action is conveyed upward to the thigh and pelvis and downward to the leg and foot.

a. Leaving the thigh flexed, abducted, and rotated outward, and making no change in the original spontaneous position except to extend the leg on the thigh at the knee.

Tension and rigidity develop in the popliteal space, along the postero-internal thigh, along the antero-internal thigh to below the symphysis pubis, and along the tendo Achillis. The resistance offered can apparently be overcome only by making tense and stretching the hamstring tendons, especially the internal going to the tibia, and to a less extent the adductor mass.

b (above); e (center); h (below).

Fig. 11. The straight and the curved cervical spine, with added demonstration of the lumbosacral anterior convex curve. a, (9-LI) Lower extremities flexed, abducted, and rotated outward. Head flexed so that the plane of the face forms an angle of about 45 degrees with the horizontal plane upon which the trunk rests, occiput resting on the same plane as the trunk; profile view of straight cervical spine, with short anterior concave curve at the upper pole (compare with Fig. 8 e *2* and *6*). b. Same subject as in Figure 9. Head flexed a little more than in 11 a, obscuring the anterior concave curve at the upper cervical pole (compare with Fig. 8 e *1* and *7*). Lower extremities extended, adducted, and rotated inward, developing forward and downward rotation of the pelvis and increasing the lumbosacral anterior convex curve. c, Same subject as in b. Long anterior concave curve of the cervical and upper thoracic spines, with extension of the head, the occiput being unrestrained and allowed to seek its normal position dorsad to the cervical spine. The flexion of the cervicothoracic spine brings the occiput far in front of the lumbothoracic spine, while the face lies in an oblique plane forming an angle of about 60 degrees with the horizontal plane upon which the lower two-thirds of the trunk rests. d, Same subject as in 11 a but head extended so that the face lies about in the frontal plane; profile view of cervical anterior convex curve (compare with Fig. 8 e *3* and *8*). e, f. Same subject as in b and c. Position similar to that in d but with the lower extremities, the pelvis, and the lumbosacral curve as in b and c. g, Same subject and same position as in d, but the occiput is unrestrained and is allowed to seek its normal position dorsad to the spine, coming to rest on a horizontal plane which is lower (dorsad) than that upon which the trunk rests but parallel to it; profile view of the straight cervical spine (compare with Fig. 8 e *4* and *5*). h, Same subject as in Figure 8 f. Position similar to that in g. i, Same subject as in b, c, e, f (9-LXIII). Position similar to g.

There may be slight forward and inward rotation of the pelvis on the same side, and sometimes slight forward and inward rotation of the opposite side of the pelvis, and this latter movement may be conveyed downward along the opposite lower extremity, this latter rotating slightly on the heel, with decreasing activity to the toes, so that the anterior superior spine of the ilium, the knee and the toes describe arcs of small circles.

b. Restoring the original spontaneous position of the lower extremities and making no change except to rotate the thigh inward:

Tension, with irregular dimpling of the fascia, develops in the neighborhood of the top, front, and outer surface of the trochanter, with a feeling of strong tension behind the trochanter and in the deeper tissues. Some of the slack is taken up over the gluteus maximus and the posterior part of the gluteus medius.

c. Restoring the original position and making no change except to adduct and rotate inward the thighs (adduction so that the knees approach each other and the patellæ look forward being always accompanied synchronously by inward rotation):

The first effect is to lift up the lax tissues between the crest of the ilium and the knee, and on the posterolateral aspect of the thigh—increasing the trunk-thigh lateral angle and transforming it into an anterior trunk-thigh angle. It also makes tense the tissues between the crests of the ilia, and from the crest of the ilium to the knee, forming a plane of tension between the crest of the ilium and the trochanter, and a broader line of tension between the crest of the ilium and the knee, in the form of a broad shallow groove down the outer side of the thigh (Compare Fig. 2 a with Fig. 14 a).

The lateral pelvic region is now defined between the crest of the ilium and the trochanter by the lifting upward of the soft tissues and making tense the firm fibrous tissues indicated. There is a question of tension also on the deep fascia of the back and sides, above the crest of the ilium, and of that of the abdomen between the umbilicus and the symphysis pubis.

There is no movement of the pelvis until the patella is anterior; but when on one side this latter points about toward the spine of the pubis of the same side, the pelvis begins to rotate forward and to the opposite side.

In adducting the lower extremities as they lie in spontaneous outward rotation, the heels meet first. In adducting them with inward rotation so that the patella is anterior, the anterior parts of the feet meet first and overlap; the feet tending to follow and prolong the external convex curve of the leg. If this inward swing of the feet is prevented by the coming into contact of the internal borders of the feet, they are directed forward with beginning pronation instead of forward and inward. Now, a vertical line through the center of the patella tends to fall through the line of the third or second toe, or between these toes (Fig. 6 b).

Complete adduction of the lower extremities is opposed mechanically by the large adductor mass, and the fat covering it, which protrudes and presses on the external genitals;

by the relatively great breadth of the latter; and by the apposition and tendency of the feet to overlap.

d. Restoring the original position and making no change except to extend the thighs on the pelvis, letting the legs fall over the edge of the table:

Tension develops throughout the length of the thigh. The pelvis rotates forward and downward, with arching forward of the lumbar spine and lifting forward off the table of the posterior loins. This action is more pronounced when extension of the leg precedes that of the thigh. The arching of the trunk is about one-third as much as when adduction and forward rotation of the thighs are added.

Tension from the thigh is conveyed over the patella, and around it on both sides, to the leg, causing springing forward of the leg in slight extension (similar to the patella reflex response), with increased tension over the front and sides of the leg, and suggestion of the same tension even posteriorly; also the same over the dorsum and sides of the foot.

e. Combining c and d—adducting and rotating forward the thighs and then extending the thighs on the pelvis, but leaving the knees flexed by letting the legs fall over the edge of the table, all the preceding phenomena develop in a more definite form:

The pelvis is at once rotated forward and downward on a transverse axis, the lumbar spine and loins following it. Tension develops over the anterior, internal, and external surfaces of the thighs, with deepening and broadening of the external longitudinal shallow groove; the tension extends upward to the trochanter, to the anterior, superior spine and to below the crest of the ilium, also along the trunk fascia, especially laterally between the crest of the ilium and the ribs; and through the abdominal wall strong tension is felt along the psoas-iliacus. The lower thoracic spine follows the forward arching of the lumbar spine, with rotation upward and forward of the thoracic cage, causing lengthening of the distance between the gladiolus and the symphysis pubis, with rounded prominence and increased tension of the whole anterior abdominal wall.

When the movement of the upper trunk is inhibited (as by its stability or by holding it), tension in the posterior loins is increased; when there is lessened resistance in the upper trunk, the posterior arching is increased and diffused cephalad, as above, the upper trunk sliding downward as the thoracic cage arches forward and upward.

The tension in the thighs is conveyed over the patella and around it on both sides to the legs and feet, as described in d but more markedly. The foot continues the line of the leg, which describes a slight curve, the concavity being directed mediad.

f. Adding extension of the knees to the preceding adduction, forward rotation, and extension of the thighs, all the preceding lines of tension and movement are increased in intensity, as already described in the advanced postnatal position of the lower extremities.

The longitudinal groove lengthens and becomes more strongly marked; sometimes it tends to become oblique from the neighborhood of the anterior superior spine towards the head of the fibula. There is added strong tension down the back of the thigh and leg to the heel, also down both sides of the tibia, more marked on the inner side and causing slight movement toward flexion and supination of the foot which is held firmly in the continuation of the curved line of the leg already caused by adduction and inward rotation of the thighs, so that the most distal portions of the feet are directed the most internal, and the frontal portions of the feet tend to overlap.

When this overlapping is prevented, and the heels are kept approximated, there occurs a proportionate amount of abduction, with eversion, of the feet. This can be compensated for by increased inward rotation of the thighs, separating the heels and abducting them, allowing the frontal portions of the feet to curve inward.

The tension along the legs is not only increased but the feet are carried more firmly inward at the malleoli, and the forward part of the feet tend more decidedly to overlap. If this overlapping is prevented, whichever foot presses the more strongly, forces the other into corresponding outward rotation (pronation; abduction with slight eversion).

Bowing of the legs exists even when adduction and forward rotation are complete, because of the curving of the bones of the leg in internal concavity. When adduction and inward rotation are incomplete, the bowing is continued upward to the thigh, though sometimes broken by the inward projection at the knees (Fig. 6 b; Fig. 7 c). A condition of "knock knees" is produced or favored when the legs do not follow the thighs in adduction, this failure being favored by incomplete locking of the knee joint due to incomplete extension of the leg on the thigh (Fig. 6 a; Fig. 7 b).

THE ANATOMICAL PATHS ALONG WHICH THE POSTNATAL BODY FORM IS DEVELOPED FROM THE BODY FORM AT TERM

As all the muscles in the dead body are lax and non-contractile, all the shapes, positions, actions, and movements described must be due (aside from the mechanical presence of the muscle masses, the fat masses, and the viscera) to the arrangement and connections of the firm fibrous tissues. These tissues are the bones, ligaments around and within the bony articulations, the deep fasciæ, intermuscular septa, muscle sheaths, tendons, and aponeuroses; and to some degree, the superficial fascia, and the skin. Nerve sheaths are shown to be very important, so are arteries and veins which run a straight course, while vessels which run a tortuous course can as a rule be disregarded, probably because the tortuous course does not convey tension as does the straight course. All these tissues must, in the light of the experiments here made, be considered as being the more fixed and conservative factors in determining and preserving the body form. The position spontaneously assumed by the child at term is due to relative shortness of the firm fibrous tissues along lines made strong by older biologic paths, and this explains the anatomical difficulties which beset the struggle toward the biologically more recent human type, and the tendency of the latter to spontaneous reversion toward details of the earlier, prenatal, type.

Hence, modifications of the body form are essentially due to modifications of these fibrous tissues. And the postnatal changes in the body form are essentially due to certain definite stretchings and tractions of the fibrous tissues (plus contour and other modifications due to positions and conditions of the viscera and to muscle and fat masses) and to the activity of the muscles, these latter being the agents which are continually antagonizing the innate tendency of the fibrous tissues to return toward their earlier relations. In other words, the "instinct" toward the more advanced postnatal type of body form is manifested most largely through the agency of the muscles (as well as the viscera); the "instinct" toward the conservation of the more primitive prenatal type is manifested most largely through the agency of the fibrous tissues (as well as the viscera). And whenever the muscle "instinct" lags or is obstructed, the fibrous tissues "instinct" tends to assert itself the more markedly, movement then being in the direction of reversion toward earlier (prenatal) forms.

However, the problem is not entirely stated in these fundamental terms, since both "instincts" are subject to the modifying action of many other natural laws, several of which are noted in later chapters.

Attempting at term to trace the anatomical paths and relations along and through which these fibrous tissues act, one notes that on discontinuing the external force necessary to change the lower extremities from their spontaneous position of flexion, abduction, and outward rotation to the postnatal position of extension, adduction, and inward rotation, both the thighs and the legs tend to return to their former spontaneous positions, this return being diminished in proportion as the tissues have been stretched beyond certain limits.

It is important to note that marked individual variation may exist in the firmness of these fibrous tissues. Details of some of the general variations in those of the lower extremities have been already noted in making the measurements of body heights, but variations may be found everywhere and in all individuals. Nevertheless, the general changes in body form which have been enumerated are found in every case and they may fairly be averaged.

Skin and superficial fascia. The relation of the skin and superficial fascia to details of the body form is shown in the surface markings and in the modifications of these markings which appear with changes of positions and, upon removal of these tissues, in the laxity and change of contour seen in those muscles which have no, or only thin, fibrous coverings.

Deep fibrous tissues; nerves; blood vessels; pelvis-thigh angle; pelvis-spine union. After the removal of the skin and superficial fascia, the deep fibrous tissues are exposed, and their traction and stretching and overstretching may be observed directly. One may see these tissues stretch, grow tense, grow rigid, the arteries elongate and flatten, the blood become pressed out from the stretched and collapsing veins, the nerve trunks grow taut, the fibrous planes develop pale, thin, and flaccid areas and finally shred into solution of continuity, according to the degree of antagonizing external force applied.

The tension and traction developed in particular fibrous tissues by moving the lower extremities from the at-term to the postnatal position, show that the prenatal position is due to shortening or contraction of certain deep fibrous tissues (the remnant of earlier biological positions—*rests*), while the postnatal position is evolved through the stretching and lengthening of these fibrous tissues in the definite direction of a later type—the human type.

The progress of this stretching or lengthening is unstable and in the presence of certain obstacles is itself marked by *rests*, giving rise to certain variations of body form in the postnatal evolution of the human type. As these obstacles are removed, the orderly evolution of the type is resumed, hence the importance of studying the anatomical paths along which the evolution proceeds and the obstacles which impede its progress. (The removal of these obstacles will be studied in the chapter on the *postnatal evolution of the abdomen*.)

Incisions were made across the fibrous tissues which offered resistance to the development of the postnatal position of the lower extremities. The results of these incisions justify the following deductions:

1. Flexion, abduction, and outward rotation of the lower extremities are due to shortening of the deep fibrous tissues of the anterior, internal, and external regions of the thigh, and to some extent of those of the posterior part of the thigh, including those of the great sciatic nerve; and also to connections of these fibrous tissues with the hip joint, the pelvis, and the lumbar spine.

2. Abduction and outward rotation of the thigh depend not only on the relative shortness of the fibrous tissues already enumerated,

but also on the formation of the capsule of the hip joint and its spontaneous tendency to untwist and assume a direction favoring outward rotation of the femur, with abduction.

3. Adduction and forward rotation of the thigh in the plane of the spontaneous flexion present, lock the hip joint and make the pelvis and femur practically one bone, bent at an angle opening forward and united by the shortened and thickened capsule. The size of the angle depends on the degree of spontaneous flexion present. As a result of the development of this pelvic-thigh bone, backward movement of its lower end (extension of the thigh) causes forward movement of its upper end (forward rotation of the pelvis). Associated forward passing of the lumbar and lumbothoracic spine follows, according to the firmness of connection of the pelvis with these vertebræ. But while the upper lumbar vertebræ are progressively freed from the forward pull of the (pelvic) fifth lumbar vertebra, they continue to be pulled in the same anterior direction by their direct attachment to the upper end of the femur through the psoas-iliacus muscle. When the pelvic-thigh connection is established, the only movements possible in the hip joint are a certain amount of abduction and a very slight increase in adduction. Weakness of the locking of the hip joint probably enters first through abduction, since that is less opposed than adduction.

4. Extension of the thigh favors extension of the knee, the impulse being conveyed down the leg to the foot.

5. Adduction and supination of the feet are directly related to extension, adduction, and forward rotation of the thigh and extension of the knee by the deep fibrous tissues. When the knee is not fully extended, locking of the foot in adduction and supination is diminished, abduction and pronation are favored, and these movements of the foot may lead to outward rotation of the leg and thigh, with or without torsion of the knee from within outward, with prominence of the internal condyle of the femur.

6. Extension, adduction, and forward rotation of the thigh must be accomplished by some active force not present in the dead body. Since there is no tissue which acts spontaneously and continuously in the direction of extension, adduction, and forward rotation, as the fibrous tissue does in the direction of flexion, abduction, and outward rotation, whenever the active counteracting, but intermittent, force (muscle) relaxes, the former tendency asserts itself and draws the thigh towards flexion, abduction, and outward rotation.

Dissections: Group a. Thigh, hip joint, pelvis, lumbothoracic spine, thoracic cage.

a1. Incision in the upper portion of the thigh and blunt dissection to expose the capsule of the hip joint: thorough incision of the capsule including both limbs of the Y-ligament. Then adducting, rotating inward, and fully extending the thigh, the head of the femur protrudes beyond the limit of the capsule.

The lumbar spine, the loins, and the pelvis still move forward on extension of the thigh, though less extensively and with less force. All of the muscles of the anterior and anterolateral parts of the thigh are made tense by the extension, especially the tensor vaginæ and the sartorius but also the rectus, and also the adductor region (gracilis?).

Extension also causes grooving of the surface of the thigh diagonally upward from the outer side of the knee to over the tensor vaginæ. A second groove or depression appears in front of and below the trochanter.

a2. As the skin and superficial fascia are removed, one notes that there is some relaxation of the deeper tissues. The adductor mass on the inner and posterior sides of the thigh not being confined by the deep fascia falls lax, the quadriceps femoris, tensor vaginæ, and gluteus medius are firmer. The gluteus maximus is midway between the other two groups in firmness. The leg muscles, especially those on the outer, and outer and posterior, surfaces are held firmly by the deep fascia.

a3. When adduction is added to inward rotation of the thigh, in the plane of the original flexion, there is tension on the fascia lata, especially in a grooved band which is formed in front of the great trochanter and behind the tensor vaginæ, running thence upward and backward, while a second is formed running downward to the external condyle of the femur, if not to the external tuberosity of the tibia (Fig. 14 a).

a4. Extension of the lower extremities now causes diminished forward rotation of the pelvis, apparently from diminished size of the fulcrum of the thighs and buttocks due to the removal of the mass of fat over the latter; when this deficiency is supplied mechanically, as by interposing a finger, the rotation appears to be the same as at first.

a5. When the knee is extended in the plane of the spontaneous position of the thigh, there is resulting tension on the adductor mass and on both hamstrings; when the thighs are first adducted, there is tension only in the outer hamstring.

a6. When the lower extremities are adducted and rotated inward extension at the knee is favored by outward rotation of the leg at the knee; then forward rotation of the pelvis is less marked.

a7. Leaving the thigh flexed, adducted, and rotated inward and adding extension of the leg at the knee (compare with Fig. 15 d), the line of tension disappears (compare with a10), except that it remains, much diminished, in front of the upper part of the trochanter and extending upward and backward from there. Tension is now visible

on the external condyle of the femur and external tuberosity of the tibia, and slightly in the hamstring tendons, especially the semitendinosus—but not very marked.

a8. Returning the thigh to its original position of flexion, abduction, and outward rotation, and adding extension of the leg at the knee, there is straightening of all the hamstring muscles, except the sartorius; but no pronounced tension anywhere except along the whole length of the gracilis, in the expanded aponeurosis of the inner hamstring muscles, including that covering the lower part of the sartorius, and quite marked in that extending to the posterior surface of the leg, especially on the posterior plane of the internal hamstring.

a9. When the thigh is again in the original position of flexion, abduction, and outward rotation, inward rotation of the thigh causes tension, with irregular dimpling of the fascia, in the neighborhood of the top, front, and outer surface of the trochanter, with a strong feeling of tension behind the trochanter and in deep. Some of the slack is taken up over the gluteus maximus and the posterior part of the gluteus medius.

a10. On the undissected lower extremity the line of tense fascia on the outside of the thigh does not disappear when the knee is extended (Compare with a7).

a11. Incising the fascia lata transversely midway between the trochanter and the knee causes an immediate gaping, and the tension previously present in adduction with flexion of the knee disappears and is replaced by a rounding outward of the vastus externus.

a12. Incising the fascia above the trochanter, the tension previously present lessens but does not disappear; it seems to be propagated along the septa of the gluteus maximus, giving a diffused slight flattening rather than the former broad line.

a13. Incising the gracilis causes decrease of flexion tension at the knee; there is further decrease after incising the semimembranosus, semitendinosus, and biceps, but tension remains in the septa between these two hamstring groups; tension also remains between the fascia around the knee and that which is connected with the leg. Even after incising the intermuscular septa mentioned, very marked tension is exerted by the great sciatic nerve. After incising the hamstring muscles, the leg tends more to rotate outward at the knee.

a14. Extending the thigh on the trunk and then releasing it, it springs spontaneously upward and outward into its former attitude. Incising the muscles upon the posterior surface, and also the great sciatic nerve, it is seen that the greatest tension (and this is very considerable) is exercised by the nerve and the intermuscular septa; their incision results in a lessening of the tension upward (anteriorly), but the same tendency towards abduction remains.

a15. Incising all the remaining muscles about the junction of the middle and lower thirds of the thigh (so as to leave the knee-joint intact) causes no material change. With the incision of the tissues of the thigh there is a steady decrease of action on the pelvis. A slight action remains on the lumbar spine and over the pelvic ligaments (psoas intact).

a16. Exposing the posterior region of the hip-joint, and rotating the thigh so the patella is directed forward, tension is especially strong on the obturator internus and gemelli, less on the pyriformis, and still less on the quadratus femoris. Continuing the incision through the obturator internus and gemelli is still not sufficient, but after incising the remaining muscles, and rotating the patella directly forward, it remains there spontaneously, though not quite completely—the posterior part of the capsule is very tense, so probably that draws the thigh as far as it goes toward outward rotation.

a17. Adduction now remains nearly complete spontaneously. Incising the tendon of the psoas results in adduction and inward rotation remaining spontaneously still more complete.

a18. Even when everything is removed from around the hip joints, the same forward rotation of the pelvis and the associated forward passing of the lower lumbar spine continue.

a19. When the thigh is abducted and rotated outward, in the position spontaneously assumed at term, the capsule of the hip joint runs straight, obliquely downward, and outward to the neck of the femur; the head of the femur looks forward and a little inward; the trochanter looks backward and a little outward; the lesser trochanter is directed downward, inward, and forward. The internal surface of the femur as the bone lies in this position is slightly concave.

a20. After the exposure of the unopened capsule of the hip joint, and the rotation of the thigh inward so that the patella is directed forward, the capsule is seen to be twisted on itself, making a strong bar upon which the head of the femur presses from behind. This twisting of the capsule shortens and thickens it, and so shortens the connection between the pelvis and the femur that they are made practically one bone, bent at the angle of spontaneous flexion; and whenever the lower end of this pelvic-thigh bone is moved backward, as in extending the lower extremities on the trunk the upper end of the femur and the pelvis move forward together.

a21. Extension of the thigh, especially when adducted and rotated inward, results in forward rotation of the pelvis and an anterior convex arching of the lumbar spine, or even of the lumbothoracic spine. When this latter region is affected, more or less upward and forward rotation of the thoracic cage occurs.

a22. At the same time that the already mentioned changes occur in the anterior part of the capsule, the posterior part of the capsule is twisted from below upwards, making the posterior wall of the joint thicker and firmer, and making the femur and pelvis practically one also from behind. In this position, the only movements possible within the joint are a certain amount of abduction and a very slight increase in adduction. Even when the patella is directed forward, the trochanter still looks somewhat backward, and the lesser trochanter distinctly backward.

a23. The capsule shows a spontaneous tendency to untwist, and this allows the femur to yield to the deep fibrous tissues which abduct it and rotate it outward.

a24. Dissecting all fascia and tendons away from the capsule of the knee, posteriorly, allows full extension of the leg on the thigh, but the spontaneous flexed position of the knee remains about the same, on account of the upspringing of the lower end of the femur, carrying with it the upper end of the leg. The descent of this end of the femur seems to be prevented by the twisted ligament running from just below and internal to the anterior inferior spine of the ilium to the femur, from the base of the lesser trochanter obliquely forward and upward. Cutting that, and also the anterior band going to the trochanter, is still insufficient; finally, opening the capsule allows the lower end of the femur to fall, though not completely. Incising the capsule behind and below does not make much change, but incising it behind and above allows the head to project in front beyond the capsule, and this permits the lower end finally to fall, and the knee to remain spontaneously in extension.

Dissections: Group b. Knee and foot.

b1. Extending the leg on the thigh at the knee causes marked traction on the muscular masses on both sides of the tibia, apparently most pronounced on the inner side,

and producing grooving below and in front of the internal malleolus, and still more marked behind the malleolus; it also produces tension on the scaphoid and on the sole of the foot below the bone, also along the metatarsal bone.

b2. The foot continues the line of the leg, which describes a slight curve, the concavity being directed mediad. The inner edge of the foot forms an angle opening inward at about the level of the scaphoid, or a little anterior to this bone. The first metatarsal bone and the great toe form the anterior limb of this angle; this anterior limb extends forward and still farther mediad. When the knee is extended and the fascia of the leg made tense, this position of the foot is more firmly maintained.

b3. When the knee is relaxed and flexed, and the forward part of the foot is taken hold of, this latter can be moved laterally toward the ankle, both directly and with some rotation; a similar rotation can also be developed in this region by grasping the heel from the sole. When the knee is extended these motions are much restricted.

b4. The tension which extends down along the outer side of the leg, when the knee is extended, passes to the external malleolus, thence to the sole, and also to the dorsum of the foot, especially opposite the last four toes; this last tension is best felt when making slight counter-pressure against the dorsum of these toes. The tension is also conveyed behind the external malleolus, which is drawn slightly upward and forward, the whole leg seeming to rotate inward. The same tension appears to exist on the posterior surface of the leg.

b5. The heel was originally on a higher plane than the front of the foot. Bringing the forefoot up into the same plane as the heel makes the tendo achillis tense, especially towards the inner head of the gastrocnemius, which latter appears to become displaced toward the antero-internal side (tension in fascia). It is easier to evert the foot after cutting the tendo achillis, not direct eversion but the heel rotates forward and inward.

b6. When in the original position of flexion the thighs are adducted and rotated inward, both legs and feet are held in the same relative position. The crest of the tibia looks inward and a little forward. Without changing the position of the thighs, the crest of the tibia can be brought directly forward only by outward rotation of the leg at the knee. Extension at the knee is favored by outward rotation of the leg at the knee, then forward rotation of the pelvis is less marked.

b7. When the thighs are adducted and rotated inward, the foot looks inward and a little forward; if held so, the foot can be brought directly forward by slight rotation but it can not be abducted so that the toes are directed forward and outward without being also everted.

b8. If the leg is rotated at the knee so that the crest of the tibia looks forward, the foot can be abducted slightly (10 degrees or less) without eversion. This is about the usual relation between the axes, with reference to the axis of the crest of the tibia which is directed inward to the axis of the foot, and if prolonged would terminate about the tarsometatarsal joint. To bring the foot into the axis of the tibia, the toes must be turned in.

b9. When the lower extremity is extended, adducted, and rotated inward, so that the patella looks forward, the foot curves so as to continue the internal concavity of the leg, the ends of the toes lying in an oblique line, the end of the great toe being the most distal.

b10. After the hamstring muscles are incised, the leg tends more to rotate outward at the knee. After all the muscles below the knee are incised, also the vessels and nerves, including also all the deep and superficial fascia, except such as keep the knee joint intact, the knee still returns spontaneously to flexion (a24).

From the dissections noted it might appear that the close union of the pelvis and the femur at term is due to limitations present in the capsule of the hip joint. But it will be noted that these dissections were made by examining the hip joint with the fibrous tissues of the pelvis and of the thigh more or less intact. It will also be noted that as the fibrous tissues of the thigh are incised, the action of this region upon the pelvis becomes progressively lessened (a15).

In another series of dissections, by means of fractional circular incisions of the thigh from the knee upward, extending inward to the femur, the pelvis and the capsule of the hip joint were freed from the action of all connections with the firm fibrous tissues of the thigh, and it was then found that the head of the femur moved freely within the capsule without affecting the pelvis. Hence, the inference appears justified that the pelvis is acted upon as above by the femur because of firm fibrous tissue connections between the pelvis and the femur, and between both of these and the capsule of the hip joint.

Thus, this study shows that through its firm fibrous tissue connections the thigh exerts a powerful influence upon the body form—as far caudad as the feet and toes and as far cephalad as the abdomen and thorax. Its influence caudad is seen to be exerted through the direct continuity of its fibrous tissues—not only those related to the deep fasciæ and the muscles but also those of the great nerve trunks, and affecting markedly the bones and the articulations.

Its influence cephalad is more complex. The continuity of its firm fibrous tissues is less simple and its influence is exerted more directly upon and through two other complex structures—the pelvis and the lumbar spine (both singly and in combination), and thence to the lower thoracic vertebræ and the thoracic cage, and through this latter to the cervicothoracic vertebræ and the head. We are thus led to the study of these more cephalad structures.

THE ANTEROPOSTERIOR SPINAL CURVES

Four anteroposterior spinal curves are developed in the supine position at birth—

cervical and lumbosacral anterior convexities and thoracic and sacrococcygeal anterior concavities. Of these four curves, two are organic (the lumbosacral and the sacrococcygeal) and two are functional (the cervical and the thoracic) (Fig. 8 d 1, 2; e, 3, 8; Fig. 11, e, f).

The posterior line of the spine, as one looks at the child lying in the supine position with its lower extremities in the spontaneous position of flexion, abduction, and outward rotation, and with its head in the position of the flexion which it tends spontaneously to assume, the posterior horizontal plane of the head and trunk appears to form an unbroken line from the neighborhood of the occipital protuberance to the buttocks (Fig. 8a). But this appearance is misleading and is due to the obscuring of the line of the spine by the soft tissues.

Laying the child (with the lower extremities in spontaneous flexion, abduction, and outward rotation, and with the head extended so that the face lies in the frontal plane, parallel with that upon which the trunk rests (Fig. 8b) upon a bed of soft plaster of Paris, one notes that the imprint of the spine along the back, beginning caudad, shows a slight, flattened, posterior sacrococcygeal convexity merging insensibly into a slight, very rounded lumbosacral posterior concavity which, in turn, merges almost insensibly into a very slightly marked, long, rounded, posterior thoracic convexity. This, in turn, towards the cervical region passes rather abruptly into a well-marked obtuse receding angle opening dorsad, the upper arm of the latter descending a little slowly to the horizontal plane upon which the occiput rests (Fig. 8 d1; compare with Fig. 8 g; Fig. 11 d).

Laying the child upon a second bed of soft plaster of Paris and making no change except before laying them down to bring the lower extremities into the postnatal position of extension, adduction, and forward rotation (Fig. 8 c), one notes a marked, flattened, sacrococcygeal posterior convexity merging cephalad into a well marked lumbosacral posterior concavity which merges definitely, cephalad, into a well-marked thoracicocervical long posterior convexity. This latter terminates in a receding angle, opening dorsad, as in the preceding cast. But the angle is sharper and its shorter occipital arm shows more definite markings as from increased tension and pressure (Fig. 8 d 2; compare with Fig. 11 e, f).

The cervical spine—curved and straight; spontaneous tendency toward flexion of the head and neck. When the head of the child is unsupported, it yields to gravity and falls freely either forward or backward and, less freely, to one or the other side. These bending movements take place not between the head and the spine but in the cervical vertebræ, the only direct movements of the head on the latter being the slight nodding movement of the occipital condyles on the articular masses of the atlas. In all other movements, one or more of the cervical vertebræ move with the head. The forward and backward bending movements may be direct but they tend to be accompanied by a lateral movement which adds more or less lateral rotation of the cervical vertebræ.

In the supine position, with the occiput resting on the same horizontal plane as the trunk, the head spontaneously assumes a position of more or less flexion, the chin tending to come to rest more or less above the level of the sternal notch. When the face is held anterior, the head in this position rests upon the lower part of the occipital protuberance. But it can not balance spontaneously upon this small point, so when support is removed, it tends to rotate laterally (the face looking more and more outward, as well as forward and a little downward) to one or the other side, tending to come to rest on the occipitoparietal lateral junction, on the occipitoparietotemporal junction, or even on the lateral surface of the parietal bone above the temporoparietal junction (Fig. 2 a, b, h; Fig. 3 b, e, i, j).

There is a second factor involved in the tendency to spontaneous flexion of the head in this position. With the thoracic spine as a whole resting on the table, and the upper pole of the cervical spine raised above the table to an extent corresponding with the distance at which the articular base of the occiput is placed anterior to the plane of the supporting part of the head, the cervical spine becomes the seat of a struggle between two opposing forces —the head (and its attachments) which tends to bring it into the line of the articular base of the occiput; and the thoracic spine (and its attachments) which tends to bring it into line with itself (Fig. 9 b, d). Gravity aids this latter and by facilitating the fall of the cervical vertebræ toward the table, aids in bringing the articular base of the occiput nearer the table, and so moves toward flexing the head. Then, at a certain moment, gravity acts also more on the anterior portion of the head, and so adds a more direct element toward flexion (Fig. 10 a, b). Accessory factors are such tissues as make towards keeping the cervical vertebræ towards or away from the planes of the articular base of the occiput and of the thoracic vertebræ, respectively (Fig. 8 f).

Development of cervical anterior convex curves, with or without lateral deviation and with or without lateral curvature. As soon as the child is born and falls supine upon a resisting surface, whether the head falls into spontaneous flexion or is more or less extended, it tends to develop a cervical curve the convexity of which is anterior and also a little toward one or the other side, with some rotation of the vertebral bodies toward the line of the face.

When the head falls in spontaneous flexion, with the occiput resting upon the same

supporting plane as the trunk, palpation reveals a slight, high, anterior cervical convexity (similar to Fig. 8 f), with convexity perhaps increasing somewhat and adding a lateral deviation as the flexed head falls sideways (Compare with Fig. 9 a, b, c, d).

If, now, the head is extended so that the face moves into a plane parallel with the horizontal plane upon which the trunk rests, one notes a developing tension of the soft tissues on all sides of the neck which latter narrows and elongates, this tension leading towards upward and forward traction upon the front of the thorax. The tension and traction are exerted upon the thorax both directly and indirectly, the latter through the medium of the anterior portion of the shoulder girdle, the clavicle (Fig. 3 f, g; Fig. 8, compare a and b). Palpation now reveals a more marked anterior cervical convexity which extends lower down towards the thoracic region.

A lateral deviation is added if the head is rotated to one or the other side. This lateral deviation may extend downward through the cervical region and involve the cervicothoracic junction, or even the upper thoracic vertebræ. The spines follow the occiput, so the convexity of the lateral deviation (spinous processes) is to the side opposite that upon which the head rests. The lateral deviation is accompanied by some rotation of the bodies of the vertebræ, these bodies moving in the direction of the face (compare with Fig. 9 a to h).

In connection with the lateral rotation of the head, there may be developed also a tendency toward lateral curvature of the cervical column. This is because of the fact that the final support of the head may pass to a higher or a lower level than its junction with the upper cervical pole which is thus called upon to ascend or descend, while the lower cervical pole tends to be kept near its former level by its attachments to the shoulder girdle and the thorax (Fig. 9, compare a to d with e to h). The transmitted stress increases with the extent of the rotation and as it is difficult for the cervical vertebræ to curve laterally, the stress extends directly to all the tissues of the column of the neck. Attempts to relieve this stress by turning the rest of the body to follow the head may increase the stress on the cervical column if the lower pole of this column is thus raised still higher above the supporting plane by the greater lateral extension of the shoulder to the outer side of the spine. This calls for a relatively greater descent of its upper pole to permit the side of the head to rest upon the same supporting plane. (It is important to note that the lateral position leads to a forward sliding of the whole shoulder girdle.

A cephalocervical posterior concavity, extending upward beyond the cervical region to the occipital protuberance, is more or less evident (Fig. 8 g; Fig. 9 a to h) according to the degree of backward extension of the occiput beyond the upper cervical pole and according to the amount of soft tissues present.

When the mandible, the attached tissues in front of and to the side of the cervical spine, and also the clavicle, are removed and the head is then allowed to fall forward in spontaneous flexion, the front of the cervical spine is seen lying in an anterior convex curve which is less marked than before dissection, while the back of the cervical spine and the cephalocervical posterior concavity are both obscured by the soft tissues (similar to Fig. 8 f; compare with Fig. 3 h). Then if the head is placed in midextension, so that the face is in a plane parallel with the plane upon which the trunk rests, the anterior convexity of the front of the cervical spine increases, the back of the neck is raised from the table in a posterior concave curve which merges with the now visible cephalocervical posterior concavity, both somewhat broken by the sagging of the soft tissues (Fig. 8 g). As the soft tissues are gradually removed from the mandible and from the front and sides of the cervical vertebræ, the tension and traction upon the clavicle and thorax progressively diminish, these latter falling a little downward and backward (compare Fig. 3 h with Fig. 8 g).

Removing the soft tissues from also the back of the cervical spine and from the occiput below the protuberance, but leaving the nuchal and other ligaments sufficiently intact to preserve the relations between the occiput and the cervical spine, as well as between the individual cervical vertebræ, and placing the head in forward flexion, one notes the disappearance of all the cervical curves described. The cervical vertebræ, with the exception of the atlas, and perhaps a little of the axis, lie in a straight line horizontally on the table; the ring of the foramen magnum is carried forward and looks a little backward and downward, and the atlas, owing to its close connections, follows the articular base of the occiput and, with perhaps the aid of the axis, forms the cephalic arm of a slight anterior cervical concavity. The cephalocervical posterior concavity almost disappears, the head and neck lying on the table in almost a straight line from the lower part of the occipital protuberance downward (Fig. 9 a, b; compare with Fig. 8 e 1, 7). In these illustrations, the cervical anterior concave curve does not appear because in the dissected subject, the apposition of the occiput and the atlas with the immediately succeeding cervical vertebræ is so close that the line of their separation is not shown. But as soon as the acuteness

of the angle of flexion is sufficiently diminished, by beginning extension of the head, the anterior concave curve begins to become visible (Fig. 8 e 2, 6; compare with Fig. 11 a). If the head is allowed to fall to one or the other side, lateral deviation of the cervical or cervicothoracic vertebræ appears, with more or less rotation of the bodies of the vertebræ toward the line of the face (Fig. 9 c, d).

If no change is made except to turn the face to the front, and then to extend the head until the face is in a plane parallel with the horizontal plane upon which the trunk rests, a marked anterior cervical convex curve appears. This curve is similar to the one noted by palpation as developed in the undissected neck if the head is placed in the same position, except that the curve is less rounded and below the atlas tends to sag backward, so that the curve is flattened. The neck is lifted above the table, showing posteriorly a corresponding curve which merges upward into a marked cephalocervical posterior concavity. (Fig. 9 e, f; Fig. 8 e 3, 8; compare with Fig. 11 d). Again the head is allowed to fall to one or the other side, and lateral deviation of the cervical or cervicothoracic vertebræ appears, with more or less rotation of the bodies of the vertebræ toward the line of the face (Fig. 9 g, h).

Development of the straight cervical spine, with or without lateral deviation, and with or without lateral curvature. The foregoing experiments seem to demonstrate that extension of the head develops the cervical anterior convex curve, while flexion of the head causes this curve to decrease or disappear and, especially in the dissected specimen made by removal of all the soft tissues, to be replaced by a more limited anterior convexity or even by a short, high anterior cervical concavity, the rest of the cervical vertebræ lying straight.

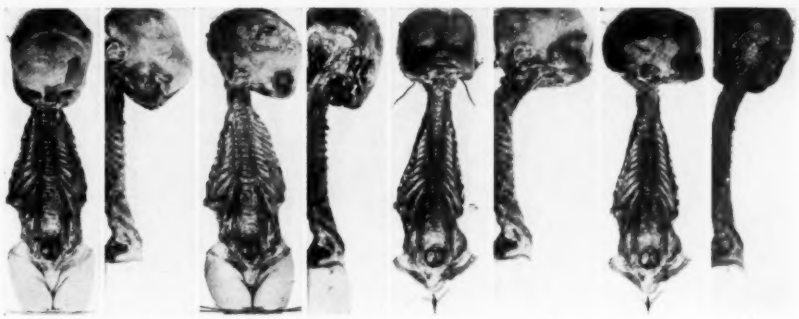
But further study of these experiments shows that the real factor in producing the above anterior cervical convexities is the anterior inclination of the cervical spine, which is developed even when the head is in spontaneous flexion by arbitrarily displacing forward the articular base of the occiput and the closely connected, more mobile, upper cervical pole into a plane which is anterior to the plane in which the less mobile lower cervical pole is held by its continuation with the more stable thoracic vertebræ. And this forward displacement of the articular base of the skull, which occurs in the supine position even when the head is in spontaneous flexion, is increased with extension of the head because in the upward and backward rotation of the head upon a transverse axis which occurs when the head is extended, the area of excursion of the back of the head is in this position limited by the resisting surface of the table upon which the head rests.

When this resisting surface is removed and the head left free to rotate, the occiput takes its normal position posterior to the cervical vertebræ, the articular base of the occiput is not displaced forward, anterior inclination of the cervical spine does not occur, and extension of the head to bring the face into the frontal plane does not produce a cervical anterior convex curve. The upper cervical pole (and its union with the articular base of the occiput) and the lower cervical pole then lie in the same plane, and the cervical spine remains straight. Secondary modifying factors are the attachments of the segments of the cervical spine, anteriorly, to the cranium and to the front of the thorax, including the thoracic portion of the shoulder girdle, and, posteriorly, to the cranium and the back of the thorax, including the back portion of the shoulder girdle (Compare Fig. 9 a to h with Fig. 10 a to h). A lateral deviation occurs also in the straight spine if the head is rotated to one or the other side. But the tendency toward the development of a lateral curvature as the result of the lateral stresses noted under the development of the cervical anterior convex curve, does not exist in the same degree because in this position the straight cervical spine is supported by the horizontal plane upon which the trunk rests (Fig. 10 c, d, g, h).

In Figure 8 f and g, it is noted that the occiput rests upon the same horizontal plane as that upon which the trunk rests, with the head extended so as to bring the face into the frontal plane, parallel to the plane upon which the trunk rests. The articular base of the occiput is displaced forward, carrying with it the upper cervical pole, thus developing an anterior inclination or flexion of the cervical or cervicothoracic spine and a cervical or cervicothoracic anterior convex curve (Compare with Fig. 8 e 3, 8).

Now (Fig. 11 h, i) if the displacing support is removed from the occiput and the cervical spine is straightened, the head is permitted to rotate freely upon a transverse axis until the face is in the frontal plane. Then if the occiput is supported so as to retain the head in this position, it is found that the cervical spine remains straight, neither anterior inclination nor flexion is developed, no anterior or posterior curves appear, and the occiput comes to rest dorsad to the cervical spine and dorsad to the horizontal plane upon which the trunk rests (compare with Fig. 8 e 4, 5).

In Figure 11 a, the occiput rests upon the same horizontal plane as that upon which the trunk rests and with the head flexed so that the face lies at an angle of about 45 degrees to the supporting plane. The articular base of the occiput looks downward and backward (caudad and dorsad) carrying with it the atlas, and perhaps more or less of the axis, making a high cervical anterior concavity or angle,



a b c d e f g h

Fig. 12. Showing the cervical curves, with the additional demonstration of the lumbosacral anterior convex curve. a to h, The same subject and the same positions as those shown in Figure 9, except that the lower extremities have been extended, adducted, and rotated inward, thus adding a forward and downward rotation of the pelvis and resulting in an extension of the lumbosacral anterior convex curve.

the rest of the cervical spine lying straight (compare with Fig. 8 e 2, 6).

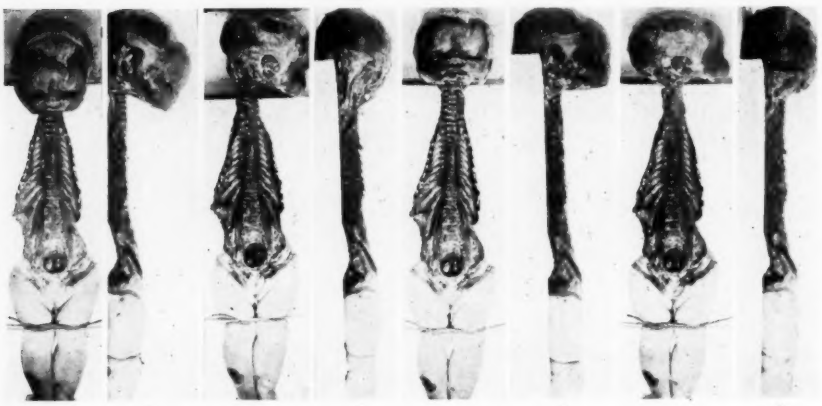
If no change is made but to rotate the head so as to bring the face into the frontal plane (Fig. 11 d), a cervical or cervicothoracic anterior inclination or flexion and a cervical or cervicothoracic anterior convex curve are developed, as in the preceding cases (compare with Fig. 8 e 3, 8).

But if the cervical spine is straightened and the head allowed to rotate in the same way, after all obstacles have been removed from the path of the occiput (Fig. 11 g), the cervical spine lies upon the horizontal plane, while the occiput comes to rest dorsad to the line of the spine. And, again, there develops no anterior inclination or flexion nor curvature of the cervical or cervicothoracic spine, this remaining straight (compare with Fig. 8 e 4, 5).

In the casts in Figure 8 e 4, 5, there is shown a high, slight anterior concavity which may be due to the fact that the occiput was brought to rest at a slightly higher level than that which would bring its articular base into exact line with the cervical spine. If the support for the occiput be not adjusted exactly, the atlas may rest on the edge of the horizontal plane supporting the cervical spine and the trunk. As a result, the articular base of the occiput may sag, and this sag transmitted to the anterior vertebral ligament may raise the cervical vertebrae in a slight anterior convex curve from the second to the seventh, with its maximum about the fourth. If, on the other hand, the articular base of the occiput rests on the edge of the horizontal supporting plane, this causes it to move a trifle forward of the line of the cervical column, perhaps carrying more or less with it the atlas, and producing a slight anterior concavity, similar to that seen in acute flexion of the head in Figure 8 e 2, 6. When the occipital support is exactly adjusted, the stress is divided equally between the anterior and posterior vertebral ligaments, and no variation in the straight cervical column is observed.

In the supine position, when the cervical spine is straight, a slight anterior convexity is seen along the ventral surface of the lower cervical and upper thoracic vertebræ (Fig. 8 e, 1, 2, 4, 5, 7; Fig. 11 a, d, g). This appears to be due to two causes: (1) the forward projection of the vertebral bodies due to the pressure forward upon the spinous processes by the resistant supporting surface; and (2) the increasing depth of the vertebral bodies and the increasing length of the spinous processes in this region. The spinous processes of the thoracic vertebræ continue to increase in length but they also become bent forward at an angle and become imbricated. As this change occurs, the anterior convexity of the ventral surface decreases and the thoracic spine appears straight; or by contrast with this temporary cervicothoracic anterior convexity and the definite lumbosacral anterior convexity, the thoracic spine may appear to show a slight anterior concavity. As the cervical vertebræ are raised, the pressure from beneath is lessened or removed, the anterior convexity of the ventral surface disappears (Fig. 11 d; Fig. 8 e, 3, 8) and the increasing depth of the bodies and backward projection of the spinous processes are clearly seen (Fig. 11 d).

Although the straight cervical spine is consistent with full extension of the head, a cervical anterior convexity may be developed by continuing the rotation of the head into hyperextension, this movement, without forward inclination or flexion of the cervical column, displacing backward the articular base of the occiput and the attached upper cervical pole (Fig. 7, compare e with d). Again, with the head extended to practically a right angle with the uppermost cervical vertebræ (the relation existing in the straight



a b c d e f g h

Fig. 13. The straight cervical spine, with added demonstration of the lumbosacral anterior convex curve. a to h, Same subject and same positions as in Figure 12, except that the occiput is unrestrained in both flexion and extension of the head, and it is allowed to seek its normal positions dorsad to the straight cervical spine, finally coming to rest on a horizontal plane which is lower (dorsad) than that upon which the trunk rests but parallel to it. Note the absence of the cervical lateral curvature when the head has been rotated to one or the other side, although the lateral deviation does appear, but to a somewhat lessened extent.

cervical spine), the cervicothoracic spine may be inclined forward in a long anteriorly concave curve. Without altering this long curve, further extension of the head (hyperextension) would lead to the development of a cervical convex curve, as just noted in the straight cervical spine (Fig. 11 c).

The cervical anterior convexity is not an organic curve at birth, but is the result of postnatal factors. The final conclusion from this study is that no cervical curves are organic at birth; all are postnatal and are developed as a result of the struggle between: (1) the instinct to bring the face into the frontal plane, and (2) an acquired forward inclination or flexion of the cervical or cervicothoracic spine. The former is antagonized and the latter is favored by the anterior connections of the head and of the neck and its viscera with the shoulder girdle and with the trunk and its viscera.

The necessity for both of these factors is illustrated in Figure 11 c. Here there has been experimentally developed: (1) a forward inclination or flexion of the cervicothoracic spine; and (2) to this has been added an unrestrained extension of the head. The result is an anterior concave curve of the cervicothoracic spine, and the face lies at an angle of about 60 degrees with the horizontal plane upon which the trunk rests. If, now, the face be brought into the frontal plane, a cervical anterior convex curve is at once developed but this requires that the head be hyperextended; whereas, if the cervicothoracic spine be simply straightened the face will be found to be in the frontal plane as the result of the unrestrained excursion of the occiput when the head was extended.

The earliest postnatal factor moving toward the development of a cervical anterior convexity is interference with the backward projection of the occiput dorsad to the spine, by the bringing of the occiput to rest upon the same plane as the more anteriorly attached spine, as in the ordinary assumption of the supine position. This factor is present even when the head is flexed, but its action increases as the head is extended. When the occiput is given free play to find its normal position dorsad to the cervical spine, the cervical spine remains straight, whether in flexion or extension.

The free movement of the cervical spine at term, when the excursion of the head is not restrained, shows that the firmer fibrous tissues connected with the bones exercise a less marked influence on variation in the relative position of the individual vertebræ than do the softer tissues (muscles and viscera) and their related fibrous tissues, the curves being more and more modified as these softer tissues are removed. Hence, it seems apparent that while the anterior inclination or flexion

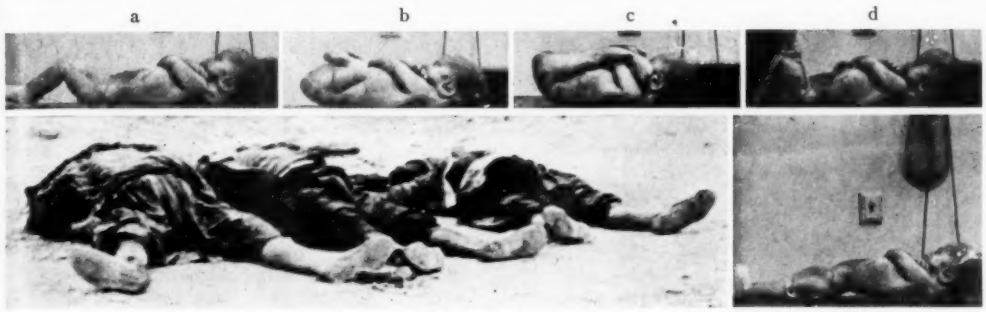


Fig. 14. Some intermediate stages occurring in the lower extremities as they pass from the prenatal position of flexion, abduction, and outward rotation toward the advanced postnatal position of extension, adduction, and inward rotation so that the patellæ look forward. a, Same subject as in Figure 1 but the head has been allowed to fall in spontaneous flexion, with slight rotation to the right, and with the lower extremities adducted and rotated forward in the plane of the spontaneous flexion of the thighs. Because of the firmness of the deep fibrous tissue contractions, there is a slight return toward abduction and outward rotation of the legs and feet. b, Same subject as in 14 a but approximate return to the intra-uterine position of flexion of the lower extremities on the pelvis, and of the pelvis on the spine. c, Same subject and same position as in b, but with increased flexion of the pelvis and lumbar spine; the knees are now extended and the thighs somewhat abducted, to allow for the increased pressure of the abdominal contents, from the increased flexion of the spine. d, Same subject and same position as in 14 a, but with the thighs adducted, rotated inward, and flexed at an angle of 90 degrees with the plane upon which the trunk rests, and held in this position by being tied just above the knees to a vertical splint. On account of the firmness of the deep fibrous tissue contractions, there is a slight return toward abduction and outward rotation of the legs and feet. e. Newly-dead adult men (*Times Wide World Photos*) showing spontaneous resumption of the at-term position of abduction and outward rotation of the thighs but with the lower extremities extended at the hip and knee joints.

of the cervical or cervicothoracic spine is determined by the relative positions of the articular base of the occiput and the lower pole of this portion of the spine, curved variations of the line of this anteriorly inclined spine depend upon variation in the balance of the muscles and viscera thereto attached, the location of the angle of flexion depending on the location of the point or points upon which the force of the flexing factors converge. Hence, the curve may develop more markedly from the upper pole or from the lower pole.

The ease with which, at term, the cervical spine can be straightened, or overflexed, or overextended, suggests that an equilibrium has been evolved in the deep fibrous tissues as well as between the muscle flexors and extensors. But the cervical viscera remain to be considered; and two facts regarding the cervical viscera attract attention in this direction: (1) these viscera are all located on the anterior or anterolateral portions of the cervical spine; and (2) nearly all of these viscera have continuous relations with the flexor surface of the trunk spine and the trunk cavities and their contents.

THE LUMBOSACRAL ANTERIOR CONVEX ANGLE OR CURVE

It has already been shown that a lumbosacral anterior convexity (angle or curve) develops in prenatal life and is present at term even when the lower extremities fall into their spontaneous attitude of flexion, abduction, and outward rotation (Fig. 8 d 1). The lumbosacral anterior convexity differs from the cervical curves in that it is an organic curve, being fixed in prenatal life by the connections of the involved bones, although it is capable of functional modification. Its basis is a more or less pronounced hyperextension of the sacrum. But the study made in Figure 17 j, k, shows that antecedent to the hyperextension of the sacrum, a lumbosacral rounded angle or an anterior convex lumbosacral curve is present in the straight spine, this angle or curve being formed by the continuation of the lumbar vertebræ with the rapidly-decreasing anteroposterior diameters of the sacral and coccygeal vertebræ.

This study has also shown how the lumbosacral curve is related to and modified by the position of the lower extremities (thighs).

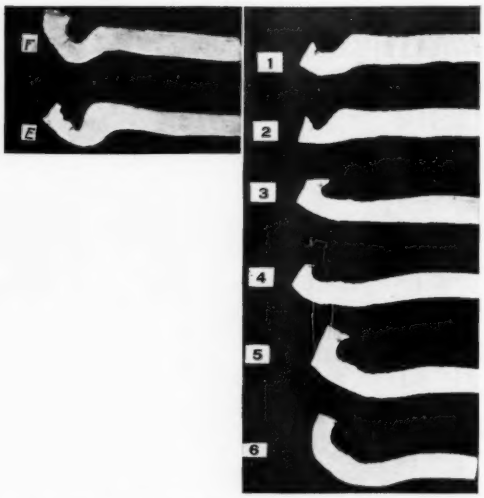


Fig. 15. Modeling of the pelvic cavity and the lower spine by the lower extremities. Note only the upper line of all these casts which are all made from the same subject as in Figure 2 d, after removal of all the viscera. The small arrow indicates the approximate location of the tip of the coccyx. *F*, Plaster cast showing along its upper edge the anterior line of the spine from the thoracic region to the coccyx (supine position) when the lower extremities are in the spontaneous position of flexion, abduction and outward rotation (compare with Figs. 2, 3). *E*, When the lower extremities are extended, adducted, and rotated inward so that the patellæ look forward (compare with Fig. 6). *1*, When the lower extremities are adducted and rotated inward in the angle of spontaneous flexion of the thighs (compare with Fig. 14 a). *2*, When the lower extremities are returned to their original, spontaneous position of abduction and outward rotation (trunk-thigh lateral angle about 135 degrees), and then extended (hip and knee joints) upon long splints (compare with Fig. 14 e).

Experimental study of one path of evolution of the lumbosacral anterior convex curve, developed retrogressively by increasing flexion of the lower extremities and pelvis upon the spine. *1*, The thighs in incomplete adduction and inward rotation are flexed so as to rest upon the abdomen, carrying pelvis and lumbar spine into flexion so that the anus looks upward and a little backward (position similar to Fig. 14c, flexion of lumbar spine more pronounced than in 14 b). In this and the succeeding casts, the plaster is introduced into the pelvis and lower abdomen through a funnel in the anus; in 5, it is introduced also through the vagina. *4*, The position is the same as in 3 except that the thighs are abducted so that the knees rest on the supporting plane just outside of the ribs, and the feet rest on the shoulders. *5*, The position is the same as in *4* but with increase of the flexion of the spine to about the lumbo-thoracic junction. *6*, The position is the same as in *5* but with increase of the flexion following increased abduction of the lower extremities so that the first and second toes rest on the supporting plane outside of the shoulders.

acting through the intermediation of the pelvis. Further study seems to show that this curve apparently develops as the anterior body concavity of the embryo straightens with extension of the spine, and that it apparently becomes fixed as the pelvic bones become attached to the spine and to each other. Thus, at term, in attempting to restore the earlier anterior concave curve of the spine by flexing the pelvis upon the spine, through the medium of the lower extremities, and carrying the flexion progressively upward, we can practically completely change the lumbosacral anterior convexity to an anterior concave curve, only a slightly projecting ridge marking the location of the former lumbosacral angle. The organic nature of the curve is shown by the persistence of this ridge in spite of the flexion as a whole, and by the compression which the act of flexion is seen to exert upon the intervertebral discs as high up as the eleventh or twelfth thoracic vertebræ. By successive separations of the pelvic bones from each other and from the spine, without other changes of position, the lumbosacral anterior convexity can be gradually but entirely removed except for the line of demarcation at the upper end of the sacrococcygeal inclined plane (the lumbosacral angle), the inclination of this plane now appearing to be due to the decreasing anteroposterior diameters of these terminal vertebræ.

In the supine position, with the lower extremities in the spontaneous flexion, abduction, and outward rotation which they assume at term, the lumbosacral anterior convexity, or angle, is present. It here appears to be due principally to the backward and downward inclination of the caudad or pelvic arm of the angle, the sacrum, the cephalad or lumbar arm being practically straight, a continuation of the practically straight, or slightly concave anteriorly, line of the thoracic spine, the two arms uniting in the rounded apex of the angle. The pelvis is rotated backward and downward, upon a transverse axis, and rests upon the upper part of the sacrum (Fig. 8 b, d 1; e 1 to 8; Fig. 9 a to h; Fig. 10 a to h).

Now when the lower extremities are placed in the advanced postnatal position of extension, adduction, and inward rotation so that the patellæ look forward, the pelvis rotates forward and downward, upon a transverse axis, and rests upon the lower part of the sacrum and upper part of the coccyx. As the sacrum (as part of the pelvis) rotates, its base is directed more forward, so it as well as the forward rotating ilia, acting through their firm fibrous attachments to the fifth lumbar vertebra, drag this latter forward. The other lumbar vertebræ are, in turn, dragged forward after the fifth, this movement decreasing from below upward as the firmness of their attachments decreases. However, the upper lumbar vertebræ are also dragged forward by the continuing pull of the femur acting through the psoas-iliacus. The result is the conversion of the lum-

bosacral angle into an extended, anteriorly convex, lumbosacral curve which may even extend upward so as to form a lumbosacrothoracic anteriorly convex curve (Fig. 8 c, d 2; Fig. 12 a to h; Fig. 13 a to h).

Beginning with flexion of the lower extremities on the pelvis, and of the pelvis on the spine, as in the intrauterine position (Fig. 14 b; compare with Fig. 1), and increasing the flexion as in Figure 14 c, but to a still greater degree, the lower extremities being more and more abducted, we find that the lumbosacral curve and angle disappear except for a slight reminiscient ridge at the site of the former angle. The lumbar spine and the sacrum now form a continuing line very slightly curved, with the concavity anterior, this curved line caudad to the line of the thoracic spine being in slight hyperextension. Several slight subsidiary ridges above and below the lumbosacral ridge show the amount of pressure and tension undergone by the intervertebral discs. The tip of the sacrum and the coccyx continue the floor of the pelvis in a curve the concavity of which looks cephalad. Hyperextension of the spine which formerly began with the sacrum is now seen beginning faintly in the upper lumbar vertebræ (Fig. 15, *3, 4*. In 3, the thighs are more abducted, so that the knees rest on the box just outside of the ribs.)

If the flexion is still more increased, the lumbosacral concave curve deepens, yielding being least in the lower lumbar and upper sacral regions; more of the sacrum enters into the pelvic floor which deepens and grows broader from behind forward. Hyperextension of the lumbar spine is now definitely indicated, being more marked above, less marked below as it curves forward to join the sacrum (Fig. 15, *5*).

Finally, increasing the flexion to about the lumbothoracic junction, we find that the crests of the ilia point practically downward and the anus points upward and a little backward. The lumbosacral concavity deepens, the higher lumbar and the lower sacral vertebræ entering into it more definitely, the lower lumbar and the upper sacral regions still yielding least. The floor of the pelvis broadens still more from behind forward, as more of the lower sacrum tends to enter into it. Hyperextension of lumbar spine is more pronounced above and less marked below (Fig. 15, 6).

When the lumbosacral anterior convex curve is developed to a maximum by extending, adducting, and rotating inward the lower extremities so that the patellæ look forward, and then an incision is made through the symphysis pubis, the lumbosacral anterior convexity shows a definite relaxation and flattening of the curve (Fig. 17 a, b). If additional incisions are made through both sacro-iliac articulations, the lumbosacral anterior convexity shows a much more marked relaxation and flattening of the curve (Fig. 17 c, d). The extension of the sacro-iliac incision on the right side upward through all the soft tissues to the twelfth rib, causes further marked relaxation and almost complete disappearance of the curve, with sagging of the left pelvis and loin, rotation of the pelvis and lumbar vertebræ to the left, and development of a long, left lumbothoracic convex curve which can be traced as high as the second thoracic vertebra. On the left side, the tense psoasiliacus is seen holding up the left pelvis (Fig. 17 e, f).

Connecting the right lateral incision with that through the symphysis, and continuing it upward along the right side of the whole spine, we note that the lumbosacral posterior concavity has disappeared, but light may still be seen in a small arc, and tension on the left psoas iliacus is well shown. Remains of the long left convexity can be traced, especially in the midthoracic vertebræ but the lower thoracic and especially the upper lumbar vertebræ are drawn to the left by the psoas iliacus and quadratus lumborum, the sacrum and coccyx swinging to the right, because of the separation of the sacro-iliac articulation (Fig. 17 g, h).

After the removal of all tissues on the left of the spine, as previously done on the right, the spine lies straight and flat, the only trace of curvature being the postural anterior convexity at the cervicothoracic junction already noted (the anteroposterior diameters of all the vertebræ increasing with the sum of the diameters of the bodies and the backward projection of the laminæ and spinous processes, as the spine rests on a non-yielding surface) and the anterior convex curve of the anterior surface of the junction of the fifth lumbar vertebra with the sacrococcygeal inclined plane or anterior concave curve, no posterior spinal concavity existing when the head is allowed to extend without obstruction to the occiput (Fig. 17 i, j, k).

SACROCOCCYGEAL ANTERIOR CONCAVE CURVE

The sacrococcygeal anterior concave curve is an organic curve developed in prenatal life and present at term.

Beginning with the attempt to restore the embryonic anterior concavity of the spine from the lower thoracic region to the coccyx (Fig. 15, *6*; compare with Fig. 16, 17, 15-16 and with Fig. 14 c), and reversing the steps of this experiment, one sees that, progressively as the flexion of the lumbar spine and pelvis decreases and moves into extension, the lumbar spine decreases in hyperextension and falls into line with the thoracic spine, the latter losing the slight concavo-convex line developed by the stress from below and be coming straight (or with a very slight anterior concave curve) (Fig. 15, *5, 4, 3, F;* compare with Fig. 16, *15-16, 13-14, 11-12, 1-2*, and with Fig. 14 c, b, d; Fig. 2 a). At the same time, the sacrum first follows the lumbar spine in becoming straight (Fig. 15, *4, 3*, and then moves into hyperextension (forming the lumbosacral angle whose apex is directed anteriorly), being now directed obliquely downward and backward with a tendency to become slightly concave anteriorly, particularly in its lower portion (Fig. 15 *F;* compare with Fig. 16, *1-2* and with Fig. 2 a). The coccyx follows the sacrum but does not so entirely lose its forward direction, thus giving with the lower part of the sacrum a definite suggestion of anterior concavity to the posterior wall of the pelvis (Fig. 15 *F;* Fig. 8 e 1 to 8, compare with Fig. 16, *1-2*).

However, other processes than extension and hyperextension of the spine are involved in the production of the sacrococcygeal anterior concavity. Figure 17 i, j, k show the

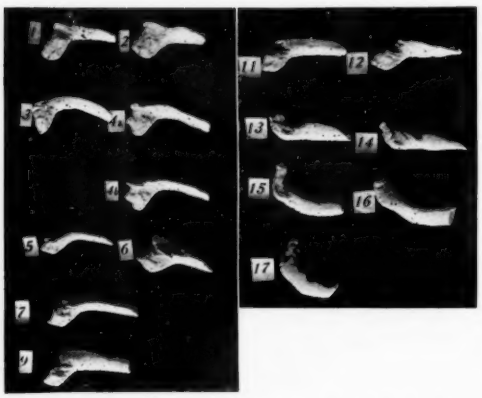


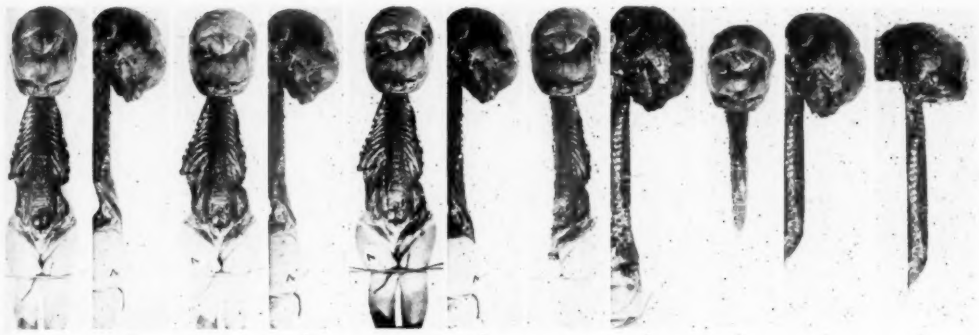
Fig. 16. Modeling of the pelvic cavity and the lower spine by the lower extremities similar in the two sexes. Note only the lower line of all these casts; supine position viewed from the left. As these casts are made in the reverse in order to show the pelvic cavity as a solid, the transverse processes of the vertebræ project so as to obscure in profile the curve of the bodies, hence the former have been carved away so as to reveal the latter along the median line. The small arrow indicates the approximate location of the tip of the coccyx. Odd numbers indicate the female studied, 9-XII; even numbers, the male, 9-XXXVII. *1, 2.* The lower extremities are in spontaneous flexion, abduction, and outward rotation (compare with Fig. 15 F; also with Figs. 2, 3; Fig. 8 d-1, e; Figs. 9, 10). *3, 4a, 4b,* The lower extremities are extended, adducted, and rotated inward so that the patellæ look forward (compare with Fig. 15 E; Fig. 6; Fig. 8 c, d 2; Figs. 12, 13). In 4a, inward rotation is incomplete, the heels being together and the patellæ and toes looking a little outward, similar to Fig. 6 g; Fig. 7 e. In 4b, inward rotation is complete so that the patellæ look forward and the toes look forward and inward, the heels being separated, similar to Figure 6 a to c. *5, 6.* Lower extremities in spontaneous flexion, abduction and outward rotation. Without altering the angle of flexion, the thighs are then adducted and rotated inward so that the patellæ look forward (compare with Fig. 14 a). Cast *6* slipped a little out of position as the photograph was being taken, 8 hence the line of the curve on the plate was changed though it remains relatively the same as in cast *5.* 7, Similar to *5, 6* but the thighs are flexed on the trunk at an angle of 90 degrees, the knees falling as they will in flexion (compare with Fig. 14 d). *9,* Similar to *7* but the knees are now extended and tied to a posterior splint (compare with Fig. 14 d). *11, 12,* The thighs are flexed, abducted, and rotated outward, the legs are flexed so that the feet overlap; the pelvis is apparently not raised from the table, and the tuber ischii and anus look downward in nearly the same plane as that of the trunk (compare with Fig. 14 *a, d* for position of pelvis; position of lower extremities approaching Fig. 14 b). The casts show a slight increase of pelvic flexion over that in F. *13, 14.* Similar to *11, 12* but flexion of the pelvis is increased so that the knees come to rest on the horizontal plane of support, outside of the ribs; tuber ischii and anus point upward at an angle of about 45 degrees (compare with Fig. 14 b). Cast *13* is made through the vagina; cast *14* through the anus. Approximate restoration of the sacrum to the plane of the lumbar vertebræ. The anterior prolongations of the casts correspond with the cavity outside the bony outlet of the pelvis. *15, 16.* Similar to *13, 14* but flexion of the pelvis is increased so that the crests of the ilia look practically downward and the tuber ischii and anus upward. The curve of flexion of the trunk is gradual and distributed along the lumbar, and lower half of the thoracic vertebræ (compare with Fig. 14 c). *17.* Similar to *15, 16* but the thighs are fully flexed and somewhat adducted, and the knees are fully extended and held in this position by a posterior splint. This brings the feet under the chin and necessitates hyperextension of the head over the edge of the table (compare with Fig. 14 c).

marked changes which have taken place in these vertebræ as compared with those more cephalad, especially in the direction of diminution of their ventrodorsal diameters, this factor tending to produce an anterior oblique or concave line when seen in profile, even though no posterior convexity appears.

MODELING OF THE PELVIS

Modeling of the pelvis (the abdominal floor) by the lower extremities and the lower spine. This study has previously shown that flexion and extension of the lower extremities (thighs) produce, respectively, backward and forward rotation upon a transverse axis of the pelvis as a whole; and the preceding study of the lumbosacrococcygeal spine has shown marked changes in the modeling of the posterior wall of the pelvis as this latter structure is more and more flexed upon the spine (Fig. 15, *3* to *6*, compare with Fig. 16, *11* to *17*, and with Fig. 14 b, c, d).

Summing up the intrinsic modeling of the pelvis at term by the lower extremities (thighs), in the supine position, one notes that flexion of the thighs moves towards making the pelvic cavity more rounded; less deep; broader laterally; and broader caudocephalad; with relaxation of the floor (Fig. 15 *F;* compare with Fig. 16, *1-2*, and with Fig. 2 a). While extension of the thighs moves toward making the pelvic cavity more funnel-shaped; deeper; narrower laterally; and narrower caudocephalad; with advancement ventrocephalad of the floor (Fig. 15 *E;* compare with Fig. 16, *3-4a, 4b*, and with Fig 14 f). Furthermore, the most complete intrinsic modeling of the pelvis is due both to extension and to adduction and inward rotation of the thighs, plus extension of the knees, this modeling being most complete in the advanced postnatal



a b c d e f g h i j k

Fig. 17. Experimental study of a second path of evolution of the lumbosacral anterior convex curve, developed retrogressively by successive sections of the attachments of the pelvic bones to each other, to the spine, and to the thighs. Consequent reduction of the spine to its earlier condition of absence of all organic curves except the lumbosacral angle which latter now appears to be due merely to contrasting anteroposterior deficiency in the sacrococcygeal vertebræ. a, b, Same subject as in Figure 13 (9-LXIII). The lumbosacral anterior convex curve is developed to its maximum by extending, adducting, and rotating inward the lower extremities. Then, section through the symphysis pubis results in a definite relaxation and flattening of the curve. c, d, Added incisions through both sacro-iliac articulations result in a marked increase in the relaxation and flattening of the curve. e, f, Extending the right sacroiliac incision upward through all the soft tissues to the twelfth rib, causes further marked relaxation and almost complete disappearance of the curve, with sagging of the left pelvis and loin, rotation of the pelvis and lumbar vertebræ to the left, and development of a long, left, lumbothoracic convex curve which can be traced as high as the second thoracic vertebra. The left psoas-iliacus is seen holding up the left pelvis. g, h, Connecting the right lateral incision with that through the symphysis, and continuing it upward along the right side of the whole spine, the lumbosacral posterior concavity disappears from view, though light may still be seen through in a small arc, and tension on the left psoas-iliacus is well shown. Remains of the long left convexity may be traced, especially in the midthoracic vertebræ, but the lower thoracic and especially the upper lumbar vertebræ are drawn to the left by the psoas-iliacus and the quadratus lumborum, the sacrum and coccyx swinging to the right, owing to the separation of the sacroiliac articulation. i, j, After removing all tissues on left of spine, as already done on the right, and flexing the head, we find that the whole spine lies straight and flat, the only trace of curvature being the slight anterior concavity at the upper cervical pole, the slight anterior convexity at the cervico-thoracic junction (both of these curves having been already noted as being functional and been so demonstrated), and the anterior convex curve, or angle, formed by the junction of the fifth lumbar vertebra with the sacrococcygeal inclined plane or anterior concave curve, no posterior spinal concavity appearing. k, When the head is extended and the excursion of the occiput dorsad to the spine is unrestrained, the anterior concavity of the upper cervical pole disappears.

position of the lower extremities, i.e., extension, adduction, and inward rotation.

a. The spontaneous position of flexion, abduction and outward rotation of the lower extremities (thighs) is accompanied by a practically straight lumbothoracic spine and by an obtuse lumbosacral angle (apex ventrad) rather than by a very definite lumbar anterior convex curve. From this angle the sacrum is directed obliquely dorsocaudad to the horizontal, then slightly curving caudoventrad it forms a short curve whose concavity looks ventrad. The pelvic cavity is rounded, resembling the end of an elongated melon. The pelvic floor looks rather directly caudad; it is almost vertical (dorsoventrad) but forming a slight curve whose concavity looks cephalad (Fig. 15 *F;* compare with Fig. 16, *1-2*, and with Fig. 2 a).

b Then the adducting and the rotating inward of the thighs so that the knees approach each other (without materially altering the angle of flexion) cause a definite convex curve to appear in the lower lumbar vertebræ, the upper lumbar and lower thoracic vertebræ sagging a little into slight anterior concavity before the former straight line of the thoracic spine is regained. The stress upon the spine is shown by the projection of the intervertebral discs from the fifth lumbar to the eleventh thoracic. The sacrum passes obliquely dorsocaudad, as in 15 F, but apparently to a less extent, passing into the sacrococcygeal concavity which looks ventrad. This concavity is lengthened, and it is more flattened, approaching the horizontal. And while the dorsoventral depth appears shallower, it is really the same in its more cephalad portion and increased in its more caudal portion. The pelvic cavity has now become bowl-shaped; its cephalocaudad diameter is lengthened; it is narrowed laterally; and its depth is increased toward the pelvic floor. The pelvic floor is directed a little more obliquely ventrocaudad, beginning more abruptly toward the tip of the coccyx (Fig. 15, *1*; compare with Fig. 16, *5-6*, and with Fig. 14 a).

c. Then if extension of the thighs and knees is added, the lumbar anterior convex curve becomes more pronounced and extends further cephalad, involving more or less of the thoracic spine. The lumbosacral angle approaches a well-rounded right angle: all the lumbar and some of the lower thoracic vertebræ project ventrad in a marked anterior convex curve, decreasing cephalad and sagging into a slight anterior concave curve just before the straight line of the thoracic spine is regained. The sacrum passes dorsad almost at a right angle and almost in a straight line which includes the upper part of the coccyx. The rest

of the coccyx forms a short, relatively deep, concave curve which looks almost directly ventrad toward the inlet of the pelvis. The pelvic cavity has now become funnel-shaped and much deepened. The pelvic floor is still more oblique, being inclined dorsocaudad at an angle of nearly 45 degrees with the horizontal; it is also advanced or pushed cephalad, thus decreasing the pelvic cavity dorso-ventrad. Its internal surface looks ventrocephalad and consists of two small, well-rounded masses which project into the pelvic cavity, the larger beginning at about the tip of the coccyx and continuing ventrad with the smaller which lies below the symphysis.

The foregoing description is of the pelvic floor as seen in the profile cast, Fig. 15 *E;* compare with Fig. 16, *3-4a, 4b;* and with Fig. 14 f. When the pelvic cavity is viewed as a whole—Figs. 12 and 13; compare with Figs. 9 and 10—there are seen to be three of these rounded masses marking the floor of the pelvis, two at the back projecting inward on each side of the rectum and in the region of the pyriformis—great sacrosciatic foramen—and one that is broad and projects across the median line below the symphysis pubis. When incised these masses are found to consist largely of fat, and evidently represent the soft tissues of the floor which are pushed upward and inward by the approximated thighs and by the increased tension in the connected deep fibrous tissues.

d. Returning to the original spontaneous position of flexion, abduction and outward rotation of the lower extremities (thighs), as in Fig. 15 *F* (compare with Fig. 16, *1-2;* and with Fig. 2 a), and omitting adduction and inward rotation but proceeding at once to extension of the thighs and knees in the original position of abduction and outward rotation (compare with Fig. 14 e), one finds (Fig. 15, *2*) the lumbosacral angle a trifle less obtuse than in 15 F but with the apex more rounded and forming part of a short but marked anteriorly convex lumbar curve which falls into a slight anteriorly concave curve before the straight line of the thoracic spine is regained. The lumbar and lower thoracic intervertebral discs project slightly, and there is marked tension along the psoas-iliacus. The sacrum passes dorsocaudad slightly less obliquely than in 15 *F* and to a somewhat greater extent, carrying with it more of the coccyx. The coccyx then passes ventrad a little more obliquely after a shorter curve. The pelvic cavity is less rounded than in 15 *F* and has moved toward the funnel shape of 15 *E.* narrowing caudocephalad as by the advancement of the floor, as in 15 *E.* Its depth is slightly increased and it is narrowed laterally. The pelvic floor is inclined more obliquely (dorsocaudad) than in 15 *F* but less so than in 15 *E.*

THE THORACIC SPINE

The straight thoracic spine; the anteriorly concave thoracic spine. In the supine position, when the adjacent cervical and lumbar spines are straight the thoracic spine is straight; when the adjacent cervical and lumbar spines are curved in anterior concavity, this latter curve may extend into the thoracic region (Fig. 11 c; Fig. 15).

When the forward pressure of the resisting surface of the table upon the increasingly backward projecting spinous processes produces an anterior convexity at the cervicothoracic junction, a slight relative concavity of the adjacent thoracic spine is produced. (Fig 8, e 1, 2, 4, 5, 7; Fig. 11 a, g, compare with d; compare with Fig. 17 j, k).

In proportion as cervical and lumbar anterior convex curves extend into or involve the adjacent thoracic vertebræ, a more or less marked relative anterior concavity of the adjacent thoracic spine is developed (Fig. 8, d 2, e 3, 8; Fig. 9, compare with Fig. 10; Fig. 12, compare with Fig. 13). Hence, anterior concavity of the thoracic spine is a functional and not an organic curve, and it is related to both the cervical and the lumbar spines.

Comparing the lumbosacral anterior convex curve when the cervical spine is curved as the result of the occiput resting upon the same horizontal plane as the trunk, with that seen when the cervical spine is straight as the result of allowing the occiput to come to rest in its normal position dorsad to the horizontal plane upon which the trunk rests, we see that in the former position the lumbosacral anterior convex curve appears deeper but extends less cephalad into the thoracic spine; while in the latter position it appears less deep but extends higher cephalad into the thoracic spine (compare Figs. 12 and 13).

ROTATION OF THE THORACIC CAGE

The thoracic cage has already been noted as rotating upward and forward upon a transverse axis when the lumbar anterior convex curve developed by extension, adduction, and inward rotation of the lower extremities extends cephalad so as to involve the lower thoracic vertebræ. It has also been noted that this action is accompanied by increased stress upon the abdomen and its contents, with forward projection of its anterior wall, and by downward and forward rotation of the pelvis upon a transverse axis with descent of the symphysis (compare Fig. 14 f with Fig. 2 a; Fig. 8 c with 8 a; Fig. 6 e, f, g, h, with Fig. 3 i, f, g, h).

A similar upward and forward rotation of the thoracic cage occurs when the upper extremities are raised either in front or at the side so that the humerus approaches the side of the head (ear) (Fig. 8 h, compare with 8 a), this raising of the upper extremity meeting with greater resistance in proportion as the elbow is extended. If this resistance be disregarded and the elbow extended, the upward and forward rotation of the thoracic cage is increased (Fig. 8 i). As the thoracic cage is thus pulled upward and forward, it tends to

drag the lower thoracic or thoracicolumbar vertebræ forward into anterior convexity, and to cause changes in abdominal stress and projection of the anterior walls similar to those just described. This rotation of the thoracic cage, with its accompanying abdominal changes, tends to be increased when the head is extended (Fig. 8 j), and also when the lower extremities (thighs) are extended, adducted, and rotated inward so that the patellæ look forward (Fig. 8 c), the rotation and its connected changes reaching their maximum when all three factors are combined (Fig. 8 k).

Rotation of the thoracic cage by the upper extremities is due to contractions (relative shortness) of the deep fibrous tissues connecting these extremities with the trunk, and the forearm with the arm. These fibrous tissue contractions have a biological origin similar to those connecting the lower extremities with the trunk and the leg with the thigh, but they are much less extensive than these latter. In the most advanced postnatal development of the human type, the humerus can be raised to the side of the head (ear) without acting upon the thoracic cage, spine, or abdomen.

A third form of upward and forward rotation of the thoracic cage, with similar abdominal involvement, is observed in connection with some activities of the diaphragm. This form will be studied in the next chapter, on *The experimental development of the splanchnoptoses and their relation to the body form.*

SUMMARY

1. The evolution of the human type is not completed at birth. The position of flexion, abduction, and outward rotation which the lower extremities (thighs) spontaneously assume at term marks a stage in their evolution from an earlier biological position towards the advanced postnatal human position of extension, adduction, and inward rotation so that the patellæ look forward.

2. Similarly, the upward and forward rotation upon a transverse axis of the thoracic cage, observed at term when the upper extremities are raised, either in front or at the side, so that the humerus approaches the side of the head (ear), marks a stage in the evolution of these extremities from an earlier biological position toward the advanced postnatal position in which the humerus can be raised to side of head (ear) without acting upon the thoracic cage, spine, or abdomen.

3. The human prenatal and at term positions of both the upper and the lower extremities have demonstrable functional advantages in sub-human types of animal life, but persistence of these positions in the human being indicates retarded, incomplete, or reversive evolution of the individual in these directions. Tendencies toward this persistence are always present until the advanced evolution of the body form is attained. Even when attained, this body form tends to be more or less unstable according as one or the other of two "instincts" is the more dominant. The "instinct" toward the more advanced postnatal type of body form is manifested most largely through the agency of the muscles (as well as the viscera); the "instinct" toward the conservation of the more primitive prenatal type is manifested most largely through the agency of the fibrous tissues (as well as the viscera) which are relatively short along lines made strong by older biological paths. Whenever the muscle "instinct" lags or is obstructed, the fibrous tissues "instinct" tends to assert itself the more markedly, movement then being in the direction of reversion toward earlier (prenatal) forms.

4. The at term position of the lower extremities is due to firm contractions (relative shortness) of certain of their deep fibrous tissues and the connections of these fibrous tissues with those of the pelvis and lower spine, and through these latter with the more cephalad parts of the body.

5. Changes in the developing positions of the lower extremities and their connections, are intimately related to modifications of the body form, particularly with reference to all abdominal walls (anterior, posterior, lateral, superior, and inferior), as well as to modifications of the positions of the contained viscera in the direction of splanchnoptoses.

6. The abdominal walls are thus so intimately co-ordinated with the spine, the pelvis, the thorax, the upper and the lower extremities, and even the head, that some

study of all these latter is necessary to an understanding of the former.

7. As the advanced postnatal position of the lower extremities (thighs) in the direction of extension, adduction, and inward rotation so that the patellæ look forward, is experimentally developed at term, in the supine position, the following changes in the body form occur synchronously: the trunk-thigh lateral angle disappears, and the whole trunk appears to narrow and elongate; the pelvis rotates downward and forward on a transverse axis, and the symphysis pubis descends; the lumbosacral region arches forward in marked anterior convexity; this anterior arching may involve the lower thoracic spine and then upward and forward rotation of the thoracic cage upon a transverse axis is added; the abdominal cavity is contracted from behind forward by the throwing forward of the lumbosacrothoracic and the iliac regions, and it appears narrowed from side to side, especially in the region of the loins; the viscera are thrown forward and downward, causing increased stress upon the anterior and anterolateral walls which are lengthened by the descent of the symphysis (and perhaps also by the ascent of the thoracic cage), while the back appears shortened by the increased lumbosacrothoracic posterior concavity. The relations of the femur are changed so that it is now convex forward, instead of forward and outward, the outer surface of the great trochanter looking backward and outward, instead of backward; modeling of the trunk, pelvis, thighs, legs, and feet develops. The legs describe a slight curve with the concavity mediad instead of forward and inward; and the feet continue the curve of the tibia, causing supination of the feet with a tendency of the forward part of the feet to overlap.

8. At term the supine position reveals four anteroposterior spinal curves: two organic (the lumbosacral and the sacrococcygeal) and two functional (the cervical and the thoracic).

9. The cervical anterior convex curve is developed as a result of the struggle between (a) the "instinct" to bring the face into the frontal plane, and (b) an acquired forward inclination or flexion of the cervical or cervicothoracic spine. The earliest postnatal factor moving toward the development of a cervical anterior convexity is interference with the backward projection of the occiput dorsad to the spine, by bringing the occiput to rest upon the same plane as the trunk, or upon a more anterior plane, as in the ordinary assumption of the supine position, thus producing a forward inclination or flexion of the more anteriorly attached cervical or cervicothoracic spine. This factor is present even when the head is flexed but its action increases as the head is extended. When the occiput is given free play to find its normal position dorsad to the spine, the cervical spine remains straight, whether in flexion or extension. The straight and the curved cervical spine assist, respectively, in the elevation or depression of the thoracic cage.

10. The experimental evolution of the lumbosacral anterior convex curve may at term be developed retrogressively along two paths, and it seems to show that this curve apparently develops as the anterior body concavity of the embryo straightens with extension of the spine, and that it apparently becomes fixed as the pelvic bones become attached to the spine and to each other.

11. Progression toward the development of the advanced postnatal position of the lower extremities assists in modeling of the pelvic cavity and the lower spine, this modeling being similar in the two sexes. The pelvis is constantly in a condition of unstable equilibrium, so its angle of inclination, its axis, the contents of its cavity, and its relations as the floor of the abdominal cavity, are continually shifting more or less.

12. The upper extremities and the head modify the body form largely through the spine and through their action upon the tendency of the thoracic cage toward rotation upon a transverse axis.

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PERIOSTEAL TRANSPLANTS IN THE REPAIR OF DELAYED UNION, UNUNITED FRACTURES, AND LOSS OF BONE SUBSTANCE[1]

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A YEAR ago I presented a paper before this society on the value of periosteal grafts in the repair of delayed union, ununited fractures, and loss of bone substance. The practical application of the method, as shown by some 10 clinical cases presented, was lost sight of in the prolonged discussion relative to "How Does Bone Grow?"—a controversy almost two centuries old in the age of modern surgery and undoubtedly a favorite bone of contention among the ancients.

In Surgery, Gynecology and Obstetrics, the official organ of the College of Surgeons, one finds so many articles on the experimental studies of bone regeneration that the student is soon lost in the maze of conflicting statements. Reviewing this journal from its last issue back to January, 1921, one finds at least a half dozen articles dealing with this controversial subject. Other journals, especially the German and French, are replete with similar articles.

S. F. Haas (4), quoting Keith, gives an excellent review of the theories and beliefs held by many investigators down to the present time. As a result of his own experiments, Haas ascribes the greatest osteogenesis to the periosteum; a certain amount of osteogenesis to the endosteum—an ability to form new bone cells but lacking the power to cement together the fractured fragments—and very little, if any, osteogenesis to the cortex when stripped completely of its periosteum and endosteum.

Since Haas' publication, Carl Rohde (7), of Freiburg, Germany, has published an exhaustive experimental study of "How Does Bone Form?" He found three sources of osteogenesis; namely, the chief source from the cambium or inner layer of the periosteum; the next source from the endosteum, and a certain amount of regeneration from indifference mesenchyme cells lying near or in the connective tissue surrounding bones. (He ascribes bone formation in remote tissues of the body, as in the abdomen, in scars, in the heart muscle, etc., as due to these indifferent mesenchyme cells lying in adjacent connective tissue which through trauma, infection, toxic stimuli, or metabolic disturbances abandon their indifferent stage and begin to build bone). He feels that he has proved the ability of connective-tissue cells to undergo a metaplasia. He gives as a law the following:

"*Fundamental prerequisites for bone formation are living osteoblasts or unused remaining mesenchyme cells which can develop into osteoblasts.* These bone-building cells, living osteoblasts, take from the living organism the organic and inorganic substances needed for bone building."

Rene Leriche and Albert Policard (5), of Strasbourg and Lyons, France, have published an exhaustive study entitled: "The Problems of the Normal Physiology and Pathology of Bones" (Paris: Masson et Cie., 1926). In a short article (6) in September, 1926, they reviewed their conclusions, and here we have a new element injected into this very old controversy. They state emphatically: "The periosteum has no true osteogenic action. It checks osseous infiltration which spreads widely." (The old "limiting membrane" theory for periosteum.) They continue:

> "The periosteum does not cover an osteogenic layer with numerous osteoblasts. This conception is purely a theoretical one. It becomes necessary only if an indispensable and fundamental part is given to the osteoblasts. But when the periosteum is modified by a change of circulation or by œdema it becomes then a ground for ossification. It is passively ossified—it does not make bone in an active manner.
>
> "The formation of bone is a result of the metaplastic change in the connective fundamental substance. This metaplasia takes place in three ways: (1) transformation of the connective tissue by an œdematous infiltration with a multiplication of connective fibrils; (2) infiltration by a special substance, chemically undefined—the pre-osseous substance;

[1] Read before Chicago Surgical Society, March, 1927.

(3) deposits in that substance of a calcareous mixture of calcium phosphates and calcium carbonates. Osseous metaplasia can occur in all types of connective tissue, embryonal type, fibrous type, etc."

They further describe the characteristic changes in bone in the neighborhood of fractures, which we have heretofore ascribed to atrophy from disuse and state:

"It seems that as a result of rarefaction of bone, there is produced a localized oversupply of calcium, which provokes an osseous metaplasia in the surrounding connective tissue."

Contrary to this last statement, we have the conclusions of Allison and Brooks (1) in an article on "Bone Atrophy," to the effect that non-use of an extremity, resulting in bone atrophy, has no effect upon the regeneration of bone at the site of bone defect. They showed that bone atrophy caused no increase in the amount of organic or inorganic salts and concluded: "The process of bone atrophy is not a change in the characteristics of bone as a substance. It is a change only in the amount of bone present. The chemical composition remains unchanged."

Thus the problem of how bone regenerates, following a fracture or loss of continuity is still a muted one. In reviewing the literature and in following his own experimental work, one is impressed with the similarity of all animal experimentation on the subject and the efforts of most investigators to prove or disprove the limiting membrane theory of periosteum, the presence and location of a cambium layer, and the presence of or lack of osteogenesis in one or all of the three bony layers.

The recent work of Leriche and Policard is a notable exception to past investigation. While their conclusions may not be accepted, yet they should serve to stimulate others to attack this problem from the functional, physiological, and chemical standpoints.

As a result of all these years of experimentation by many investigators and the practical application of certain methods by various surgeons, the autogenous bone graft has become a fixture in bone surgery. At first only the cortex was transplanted and we can readily understand the contentions of Murphy and others that this graft served only as a bridge, the graft itself dying and being replaced by new bone growing out across this bridge from the ends of the fragments. Cortex alone has very little osteogenesis.

Later Albee, Lewis, Phemister, Cotton, and a host of other surgeons advocated the use of all three layers in the bone transplant-periosteum, cortex, and endosteum. Reports of their results, combined with animal experiments, seemed to prove conclusively that such a graft lived. We know from experience that it repaired the defect in a bone caused by ununited fracture, the removal of a tumor, or other cause.

However, without exact knowledge as to how the bone regeneration occurred, or which layer of the graft was responsible for its viability and osteogenesis, the practical result of reconstruction of the bony defect in the skeleton was secured. Those of us who have used this graft know its value.

Delagénière (3) opened a new chapter in bone surgery with his report of results in the use of the osteal-periosteal transplant. He describes his technique for an implant to promote regeneration of bone. It is not a graft but merely supplies the elements indispensable "for formation of bone." He declares that, contrary to what Albee says, it is possible to reconstruct any part of the skeleton and cure any pseudo-arthrosis and obtain the desired results in a simple, effectual, and more certain manner than with Albee grafts. He obtained excellent and complete results in 244 of his 273 cases. The graft should consist of the periosteum lined throughout with a thin layer of bone. The bone strengthens the transplant, holds the periosteum stretched, and keeps it in good shape to facilitate the reconstruction of the bone. A tibia can furnish about 22 centimeters of such transplants. His illustrations show how he rolls up a rectangular graft on the periosteum side to insure a proper curve to fit in its new bed. The bone-periosteum strips are implanted side by side, end to end, and overlapping the bone side toward the bone bed. The edges are slipped under the periosteum all around. When an angular space is to be filled in, he ties two sheets together at an angle, the

flaps are kept in place by suturing the soft parts.

Goodwin, in 1800, first ascribed osteogenesis to periosteum. Ollier, in 1857, described the subperiosteal resection of diseased bone showing that the repair of the defect occurred from the retained periosteum. Albee was one of the first to insist that periosteum must be included in the bone graft. Haas, and later Rohde, in their experiments attributed the chief osteogenic ability to periosteum. Delagénière emphatically claims that his osteal-periosteal transplant is superior to the bone graft because it contains more of the periosteum, the element indispensable for bone formation.

Leriche and Policard refute this claim of active osteogenesis in the periosteum but state that the periosteum is modified by change of circulation or œdema, and thereby becomes the ground for ossification—it is passively ossified.

The outstanding fact in this résumé is that *to periosteum alone, of all the bone layers, is ascribed a definite rôle in bone regeneration.*

In addition to this uniformity of opinion concerning some power in the periosteum for bone regeneration, I have repeatedly observed the following facts which give additional weight to the argument in favor of periosteal osteogenesis:

1. When the bone is exposed at operation for old ununited fractures, the cortex is roughened and completely denuded of periosteum for a distance on either side of the site of fracture. The ends of the fragments may be osteoporotic or osteosclerotic but, in either event, periosteum is absent for a variable distance from the ends of the fragments.

2. In cases of delayed union of fractures, following severe trauma or trauma from repeated efforts at reduction, which are finally operated, the periosteum is very thin, almost impossible to raise without tearing and shredding, and ofttimes has completely disappeared from the ends of the fragments.

3. In the application of a Lane plate in a recent fracture, say within the first 2 weeks, the results are far better than when a Lane plate is used in a case of delayed union or an ununited fracture. In the latter case the plate is usually applied to a bone with very poor periosteum or one completely denuded of it.

4. Subperiosteal resection of ribs, phalanges, metacarpal, and metatarsal bones for osteomyelitis, other than tuberculous, almost uniformly results in regeneration of the bone evidently from the retained periosteum. When the periosteum is completely removed with the bone proper, this regeneration does not occur or is greatly delayed.

5. We have sacrificed 8 dogs in the last year in an endeavor to secure regeneration of bone across gaps of varying lengths by means of a pure periosteal graft. In dogs, the periosteum is so thin that it is almost impossible to raise it without shredding, providing no cortex is left adherent to it. Thus far we have not succeeded in closing in this bony defect with a periosteal transplant in a single instance. We have found, however, that when we completely denude the bone of periosteum for a distance of 3 to 4 centimeters on either side of a transverse fracture, or from the ends of the fragments in the case of the removal of a small section of the entire bone, non-union results. The absence of periosteum at the site of, and adjacent to, the fracture resulted in non-union in 6 cases examined from 3 to 6 months after this operation. In 3 of these cases, bone regeneration had commenced, but in each instance it was at the margin of the periosteum and not at the ends of the fragments (Fig. 1).

From these observations and from the clinical cases about to be reported, the following conclusion is justified: *Periosteum is necessary for the regeneration of bone and therefore in cases of delayed union, ununited fractures, and loss of bone substance, periosteal transplants, when properly fitted about the site of the damaged bone, will result in healing and reconstruction of the defect.*

In making this statement, I do not claim that periosteal transplants are superior to the osteal-periosteal transplants in all cases nor to the generally recognized autogenous bone graft in certain cases. I believe in many instances a certain amount of cortex removed with the periosteum is advantageous, chiefly

because it gives strength, shape, and foundation to the transplant. I believe further, that in the larger bones where there is a considerable loss of continuity the osteal-periosteal transplant or the autogenous graft is superior to a pure periosteal transplant. But in these cases I will in the future remove as large an amount of periosteum as possible with the bone graft.

Periosteum alone, of all the three layers of bone, has received the majority of votes of all investigators as being the one layer most indispensable in osteogenesis. Bearing this in mind, let us evaluate the various kinds of transplants and grafts:

A. Cortical graft:

1. Of the least value because it contains no periosteum.

2. It serves chiefly as a means of internal splinting but as such is superior to any inorganic or heterogeneous internal splint.

B. Autogenous bone graft:

1. Of more value because it contains some periosteum.

2. Because of the narrow strip of periosteum which this graft usually contains, it is of less value than those methods which transplant larger amounts of periosteum.

3. The cutting and transplanting of this graft requires more time, a much more cumbersome technique, and considerably more trauma than either the osteal-periosteal or periosteal transplants.

4. Its one advantage over the latter two transplants is that the solid cortex contained in this graft furnishes an excellent means of internal splinting or fixation of the fragments, a point of special value where there is a wide loss of continuity.

C. Osteal-periosteal transplants:

1. Of great value because wide strips of periosteum can be removed with a thin layer of cortex.

2. Such a transplant can be removed more quickly and planted in the bony defect with far less technical difficulties than either the cortical or full bone graft.

3. It is superior to a pure periosteal graft only in those cases in which a loss of bone substance makes it necessary to hold the periosteum more firmly and in a given shape, for example, in the form of a cone or a wide plate.

4. It reconstructs the defect in the bone more rapidly than is the case with the usual bone graft—because of the presence of a greater amount of periosteum.

D. Periosteal transplant:

1. Of great value because of the large size of the transplant which can be removed, a much larger piece of periosteum than the narrow strip usually adherent to the autogenous graft.

2. It can be removed with a blunt instrument, stripped off readily and more quickly than either the osteal-periosteal or full bone graft.

3. Because of its thinness it can be wrapped about, tucked in and brought into the closest apposition with the bone fragments to be repaired.

4. It can overlap the ends of the fragments and be sutured to the edges of the periosteum remaining on the bone often at a considerable distance above and below the site of bone defect.

5. There is far less trauma to the bone from which a periosteal graft is obtained than when a complete bone graft is made. The healing of this additional wound is quicker and less painful.

6. The technique of a periosteal transplant is much simpler, can be performed far more rapidly and there is less operative trauma to the already damaged bone, especially to its adjacent periosteum which is frequently peeled off and markedly destroyed, because a greater amount of the shaft must be exposed in doing a complete bone graft, especially a sliding graft.

7. In my hands it has given quicker reconstructive results than have my cases of autogenous bone graft. I cannot thus far see any material difference between it and osteal-periosteal transplants as to rapidity of repair. I begin to believe that the latter has the advantage when there is a loss of bone substance.

We know autogenous bone grafts are a success. We know that osteal-periosteal transplants are a success and are receiving more and more favor as a simpler procedure.

The chief reason for continuing the use of pure periosteal grafts is to prove or disprove their value, and if they continue to prove successful, then they surely form the simplest method yet devised for the repair of delayed union and of ununited fractures, except perhaps those with marked loss of bone continuity.

CLINICAL OBSERVATIONS OF PERIOSTEAL OSTEOGENESIS

Animal experiments often fail to give the true counterpart of similar conditions in the human body. It would seem, therefore, that for practical surgical purposes, carefully recorded observations of our experiences with bone work in the human should receive the greater consideration in arriving at our conclusions. With this in mind, I wish to report my clinical experiences during the last 4 years with periosteal grafts leaving certain experimental problems which have grown out of the work to be reported at a later date.

In 1912, I operated on a young lady for a bone cyst of the proximal phalanx of the fifth finger. In the freeing of the soft tissues from this bone, shreds of the periosteum were peeled off also. The entire diaphysis of the phalanx was then removed and the defect was filled in with a cortical-bone graft taken from the tibia. The transplant was composed only of cortex. Subsequent X-ray examinations made at intervals of 2 to 3 weeks, showed bony regeneration occurring first along the inner margin of the transplant, *but separated from it.* There was no question but what the new bone was growing from remnants of the periosteum and not from the cortical-bone transplant. The latter showed no evidence of bone regeneration but finally became fused with the new bone growing inward from the periosteum.

This same year I resected the upper end of the humerus for bone cyst with pathological fracture in a boy of 17 years. The defect was bridged with a 6-inch bone graft from the tibia. This time I carefully included periosteum, cortex, and endosteum in the graft. Frequent X-ray observations showed bone regeneration but most marked and first noted along the periosteal side of the graft and especially between the periosteum of the host and periosteum of the graft.

During the next few years, I had several cases of autogenous bone grafts in ununited fractures, after removal of bone tumors, in repair of skull defects, and in certain plastic operations on the nose. In spite of infections, fracture of the grafts, and the usual complications the average surgeon in bone work meets, union in all cases was obtained but often months and in one case, 2 years elapsed before the desired end was gained. Observation and experience taught 3 things: first, quicker results were obtained when periosteum was included in the graft; second, the larger the amount of periosteum transplanted, the earlier did a large amount of callus form; and third, in many cases of old ununited fractures the bone fragments were sclerosed and completely denuded of periosteum, and in these periosteum as a part of the transplant was absolutely necessary.

Subperiosteal resection of a portion or of the entire shaft of a bone the seat of osteomyelitis, has been advocated by a few authors since Ollier first described this procedure in 1857. Bauman and Campbell (2) give an excellent report of this procedure in a number of cases and conclude that regeneration of the shaft takes place from the retained periosteum; that the rôle of the endosteum in the regeneration is slight and that success can be obtained in all but about 10 per cent of cases other than tuberculosis. I have performed subperiosteal resections for pyogenic osteomyelitis of the phalanges, metacarpals, and metatarsals in over 50 cases; also in several cases of the larger bones. The periosteum, often in shreds, is carefully peeled away from the diseased bone with the surrounding soft tissues. The length of the member is maintained by traction. Following this procedure, the regeneration of the diaphysis of the bone can be observed by repeated subsequent roentgenograms. The first picture will show a complete absence of bone while the subsequent films show the gradually increasing shadow of bone growing in from the retained periosteum. This periosteal regeneration of bone, stimulated undoubtedly by the infection, and over-rich in osteoblasts because of

the early stages in involucrum formation, nevertheless demonstrates for practical purposes the great osteogenic properties of periosteum.

My experience with operating upon recent fractures is limited and is becoming less extensive each succeeding year of practice. A review of the records of the last 500 cases of recent fractures admitted to my service at St. Lukes Hospital shows that in only 31 cases have open operations been performed. Experience teaches one to be content with a fair anatomical result rather than to seek for a perfect alignment of the fractured fragments as shown by the X-ray picture. The latter desire necessitates more frequent operations, the former eliminates open reductions and in the end gives quicker and more uniform good results.

When a recent fracture is operated upon, there is added to the original trauma the operative trauma. The original trauma has already done considerable damage to the periosteum as is shown by the œdema, hæmorrhage, and shredding of the periosteum. The operative trauma can add markedly to this damage. Frequently we see the bone completely denuded of periosteum during the act of exploring the site of fracture and, after reduction and some means of fixation has been applied, the wound is closed with the site of fracture still denuded of periosteum. This, to my mind, is the chief reason for the longer delay in securing union in open reduction of fractures and accounts for the greater number of non-union cases following operation as compared with closed reductions. Repeated efforts at closed reductions in the same case will likewise frequently result in non-union. Here again the additional trauma is responsible. Just as we have been so thoroughly drilled in the importance of closing the peritoneum before closing the other layers of the abdomen in order to prevent hernia, so must we drill the surgeon in the importance of covering fracture sites and bony defects with periosteum in order to prevent non-union. Therefore, whenever it is necessary to operate upon a recent fracture, the site of fracture is now always covered with periosteum after the reduction and fixation have been attained. This periosteum can usually be obtained from the shaft adjacent to the fracture, peeled off by a blunt periosteotome either completely or left attached at the margin nearest the fracture. It can then be wrapped about, laid across, and tucked in around the fracture site. It can be sutured to the periosteum on the opposite fragment or to adjacent soft tissues in order to hold it in place, and sometimes the closure of the soft tissues over the transplant is all that is necessary. Case illustrating periosteal transplant in recent fracture:

CASE 1. J. A., colored male, 22 years of age (case of Dr. Thomas A. Noble of Harvey, Illinois, and operated upon at Ingall's Memorial Hospital), sustained a fracture of his right femur, middle third, on September 10, 1925. There was marked overriding of the fragments. A Thomas splint was applied with good mechanical traction for 2 weeks but without reduction. The patient was then anæsthetized and strenuous effort at closed reduction was made but without success. The traction apparatus was again applied and maintained for 2 weeks but reduction was not obtained. At the end of 4 weeks of these efforts, the writer was called to operate upon the case. At operation the lower fragment was found displaced backward and upward (Fig. 2). A band of muscle lay between the fragments which may have accounted for the failure of closed reduction. It required considerable effort to secure a reduction and apposition of the fragments. They were held in end-to-end apposition by means of an internal splint consisting of an intramedullary beef-bone peg. By the time this was accomplished, the adjacent fragments were fairly denuded of periosteum. A periosteal transplant was obtained from the right tibia consisting of a piece of periosteum approximately 6 inches long and 2 inches wide, removed by a blunt periosteotome. As far as the naked eye could see, no cortex was attached to the periosteum and its method of removal by blunt dissection precluded the removal of cortex. This piece of periosteum was then wrapped over and across the anterior surface of the fracture. Figures 3 and 4 show the growth of this periosteum and the part it played in securing rapid union in this case. The patient was discharged from the hospital on December 26, and was walking without a crutch or cane when the X-ray of January 9, 1926, was made, just 3 months after the operation.

The next case illustrates the use of periosteal transplant in cases of delayed union. Fewer cases of delayed union are being operated upon than formerly because here again experience is proving that massage, passive

motion of adjacent joints, and persistence in treatment will usually result in the desired end. Diathermy has seemed to be of value in a number of cases in which callus formation was unduly slow. But we occasionally have a case in which the delay in union threatens to give non-union or in which the disability can undoubtedly be shortened by operative interference.

CASE 2. Miss DeY., 24 years of age (case of Dr. G. W. Walvoord, of South Holland, Illinois), sustained a fracture of the right humerus, middle third, March 6, 1926. (The middle third of the humerus and the lower third of the tibia are two sites prone to delayed union in my experience.) The case was referred to the author's service at St. Luke's Hospital for operation on May 1, 1926. At operation the site of fracture was exposed and the fragments found to be approximated about one-fourth of their circumference. The periosteum on either fragment was practically absent. No sign of callus was present. The fragments were brought into perfect alignment and held thereby with an internal splint of beef-bone peg. This peg differed from the usual round peg. It was the author's triangular-shaped peg with notches cut in one angular edge which enabled the pushing of the peg from the canal in the upper fragment downward into the intramedullary canal of the lower fragment more readily. A pure periosteal transplant was then removed by blunt dissection from the right tibia. This transplant, 4 inches long and 1 inch wide, was laid across the anterior surface of the humerus at the site of the fracture and sutured to the periosteum, where it was intact on the humerus about 2 inches either side of the fracture. The interesting fact in this case is the development of new bone along this transplant so that the callus forms an arch over the site of fracture; but no evidence of callus is present on the other surface of the humerus even 10 months after the operation was performed. In February, 1927, the X-ray examination shows this fracture united on the surface where the transplant was applied but still ununited on the opposite surface. Examination shows good strength even with this half union that is present. I believe this case is most valuable in proving the development of new bone from a pure periosteal transplant. A better and perhaps more rapid result would have followed the complete surrounding of the humerus at site of fracture with the periosteal transplant (Figs. 5 and 6).

Better results from this method have been obtained in cases of ununited fractures than by any other method heretofore employed by the author. Thus far, 30 cases of ununited fractures have been treated with or without internal splinting. In all of these cases union has resulted. In 2 of these cases, the beef-bone pegs had to be removed later because of persistent infection and in one case the peg was removed because absorption of the shaft of the bone was threatening the desired end result. Latterly I have abandoned this method of beef-bone peg internal splinting except in rare cases, as will be explained later, and the results are better.

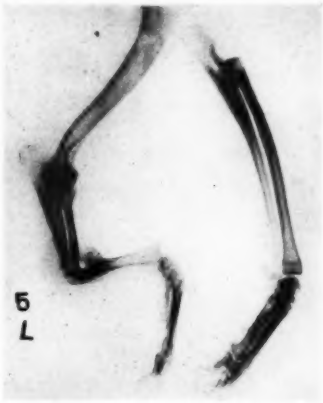

Fig. 1. Non-union in dog 3 months after operative fracture in which periosteum was stripped from ends of fractured fragments. Note the bone regeneration occurring from the margin of the rolled-up periosteum on the distal fragment and growing across the angle to unite with the proximal fragment.

CASE 3. S. G., male, 25 years of age, was referred to my service for operation for ununited fracture of the radius in November, 1924. He had been operated on by another surgeon some 8 months previously, at which time a beef-bone peg was inserted in the intramedullary canal of the 2 fragments. This operation was performed, 8 weeks after injury, for delayed union. The X-ray picture taken at the time the case first came to my attention showed this peg in position but no evidence of union. At operation the site of fracture was exposed and the fragments of the radius were found completely denuded of periosteum. The ends of the fragments were found osteosclerotic above and osteoporotic below. The beef-bone peg was holding the fragments in alignment and it showed very little evidence of absorption. The operation consisted of cutting away the ends of the fragments back to where fairly healthy bone was present. The peg was left *in situ*. The shaft of the upper portion of the radius was then exposed more thoroughly and from this a piece of periosteum about 1 inch wide and 3 inches long was raised by blunt dissection downward almost to the end of the upper fragment.

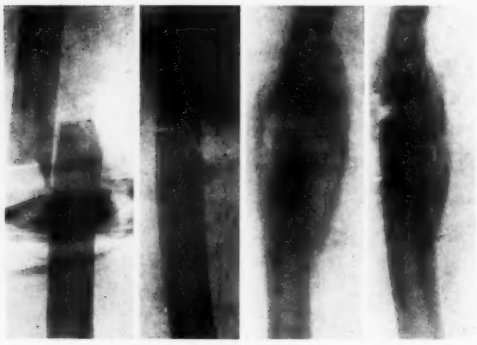

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Fig. 2. Fracture of femur, unreduced, referred for operation 4 weeks following injury.

Fig. 3. Fracture reduced by open operation and fragments wrapped with pure periosteum from the tibia. October 8, 1925.

Fig. 4. January 9, 1926. Complete union 3 months later. Wrapping the site of a recent fracture with periosteum hastens recovery.

It was left intact at this point and simply turned downward as a flap of periosteum across the gap in the bone and sutured to the periosteum on the lower fragment. By this maneuver the transplant was free at its upper end and attached and serving as a hinge at its lower end and when turned downward the inner or cambium layer of the periosteum faced outward with the outer layer of periosteum next to the bone.

In the discussion aroused when this paper was presented, some doubted if periosteum turned upside down would grow, bringing the old limiting membrane idea of periosteum to refute my claim. This maneuver has been repeated in other cases with the result that the periosteum does grow and even bridges across a bone defect. These cases make me feel that another law can be added to Wolff's law, namely: *New bone develops along the path decreed by the bone it is to replace and by the function demanded of it.* No limiting membrane is necessary to prevent new bone growing wild or in any other direction than that demanded by the body function.

The subsequent X-ray pictures taken of Case 3 (Figs. 7, 8, and 9) show definitely that new bone development started along this up side down periosteal transplant and resulted in reconstructing completely the shaft of the radius.

5

6

Fig. 5. Delayed union, 3 months after fracture of the humerus. Film taken at time of operation; beef-bone peg for internal splinting and anterolateral surface of fragments covered with pure periosteal transplant from the tibia. The transplant is not visible in the film.

Fig. 6. Complete union of that portion of the humerus covered by the periosteal transplant with non-union still present in that portion not wrapped with periosteal transplant.

CASE 4. M. B., male, 34 years of age. I am indebted to Dr. C. W. Yarrington of Gary, Indiana, for this case. The patient suffered a fracture of the upper end of the right radius and ulna 3 inches below the elbow joint, in October, 1924, the result of a street car accident. There was marked overriding of the fragments and after an attempt at closed reduction, open reduction was attempted. At the end of 4 months there was non-union and the case was re-operated upon, the ends of the fragments being held in apposition by silver wire through drill holes on the radius and by kangaroo gut on the ulna. Non-union was still present at the end of 8 months and the case was again operated upon, the silver wire being removed, the fragments freshened and held in apposition by suturing of the soft tissues. Thirteen months after the injury, the case was referred to me as one of ununited fractures.

An operation was performed at St. Luke's Hospital, November 3, 1925. Operation consisted of the exposing of the sites of fractures by 2 incisions. Both the fragments of the radius and ulna were found completely denuded of periosteum, the upper fragments of both bones were lying in close proximity and were osteoporotic. The lower fragments of both the ulna and radius were displaced outward, were osteosclerotic, especially in the ulna, and were separated from their fellows by a distance of approximately 1 inch. The drill holes through the fragments of the radius were still evident. There was absolutely no bony repair. Fibrous material, typical of non-union, lay between the fragments.

The ends of the fractured bones were removed, leaving a space of approximately 2 inches between the fragments of the radius and 1 inch between the fragments of the ulna. The medullary canals in both bones were prepared and a beef-bone peg inserted into each upper fragment in turn and then worked down into the medullary canal of the lower fragment, thus bringing the shafts into align-

ment and serving as internal splints. A small fragment of loose bone was found on the posterior aspect of the lower fragment of the radius and this was left in place. The right tibia was then exposed and a periosteal transplant, the complete width of the tibia and approximately 5 inches long, was removed by blunt dissection. A piece of fascia, approximately 2 inches wide and 5 inches long, was removed at the same time and left attached to the outer border of the periosteal transplant, thus forming a transplant composed of pure periosteum and fascia. This transplant was carried to the defect in the radius. The fascia was first sutured to the soft tissues in such a way as to form a fascial septum between the ulna and the radius. The periosteal portion of the transplant was then wrapped around the radius, forming a bridge across the defect and covering about two-thirds of the circumference of the radius. It was sutured above to soft tissues in close apposition to the bone and 2 sutures were applied below, approximating it to the periosteum on the lower fragment.

The left tibia was then exposed and a similar periosteal transplant, devoid of fascia, however, was removed by blunt dissection, no cortex being obtained, and was transferred to the defect in the ulna. This transplant covered approximately one-half the circumference of the ulna and bridged across the defect in this bone. While an assistant was closing the operative wounds in both lower extremities, the soft tissues were closely approximated about the repaired fractures in the ulna and the radius and the wounds were closed. The arm and forearm were encased in a plaster splint with the forearm flexed to approximately a right angle. Figures 10 and 11 show these fractures before the operation and 1 week following the operation. The progress of this case is illustrated by the subsequent roentgenograms (Figs. 12 and 13). Union was slow because of the marked loss of bone substance in each bone which had to be filled in by new bone before union could occur. I believe that the progress was also delayed by the presence of the beef-bone pegs, which (Figs. 12 and 13) caused considerable absorption of the cortex immediately adjacent to the pegs. Massage, passive motion, and hydrotherapy were used continuously on this arm after the eighth week, great care being exercised not to disturb the fragments unduly.

On October 1, 1926, union seemed quite firm, although the roentgenogram failed to show complete filling in of the defects. The splint was removed and the patient allowed to use the arm very slightly with the hope that function would stimulate further and more rapid growth of new bone. After 3 weeks it became evident that there was some false motion in the ulna. This was demonstrated by observing the arm under the fluoroscope. On November 12, 1926, I re-operated upon this case, making an incision over the site of the fracture in the ulna. On the lateral posterior surface of the ulna, there was a definite bridge of new bone completely across the defect but on the upper and inner surface, no new bone was present and the beef-bone peg lay in its bed completely exposed and easily movable. The radius was palpated through this wound and was found to be surrounded by a good callus and quite firm. The beef-bone peg in the ulna was removed. The left tibia was again exposed and was found to be covered with a thick, velvety periosteum which was thicker and richer in blood supply than the original periosteal transplant taken from this tibia. An osteal-periosteal transplant, the width of the tibia and 4 inches long, was removed by blunt dissection along its lateral edges but by a chisel along its middle, thus removing a thin piece of cortex with the transplant. This transplant thus consisted of an osteal-periosteal graft with osteal substance along the middle of the transplant approximately ⅛ to ¼ inch in thickness and pure periosteum along the margins. This was transplanted to the defect in the ulna, the osteal portion lying in the groove made by the removal of the beef-bone peg and the periosteal portion wrapped about the upper and inner surface of the ulna. It was held in position by a few sutures in the soft tissues and to the periosteum on the fragments above and below. Figures 14 and 15 represent the growth of this osteal-periosteal transplant and the subsequent repair in the defect in the ulna. The plaster splint was removed on December 27, 1926, and the patient was discharged with the ununited fractures completely healed and united on January 10, 1927, 14 months after my original operation for repair of non-union in these 2 bones, fractures which had gone 13 months before this treatment was instituted.

7 7 8 8 9 9

Fig. 7. Ununited fracture of radius operated on November 3, 1924; film taken November 30, 1924; showing periosteal transplant removed by blunt dissection from the proximal fragment and turned downward as on a hinge bridging the 1-inch defect in the bone; thus the periosteal transplant was upside down, the inner layer pointing outward. The internal splint is a beef-bone peg placed in the medullary canal 8 months previously.

Fig. 8. Same case as in Figure 7, 6 months later. Note the thickness of the periosteal transplant showing that all of the regeneration has taken place in the transplanted periosteum.

Fig. 9. Same case as in Figure 7, showing the completed reconstruction of the defect in the radius.

10 11 12 12 13 13 14 15 15

Fig. 10. Ununited fractures of the radius and ulna, 13 months after the injury and already operated upon three times.

Fig. 11. Same case as in Figure 10; 1 week after author's operation with fragments held in alignment by beef-bone pegs and the defects in the bones bridged by pure periosteal transplants from respective tibiæ. These transplants do not show in the films until 2 to 3 weeks later.

Fig. 12. Same case as in Figure 10, showing the filling in of the defects in the bones 3 months after operation.

Fig. 13. Same case as in Figure 10; taken 10 months later showing that the radius which was more completely surrounded with periosteal transplant has undergone greater repair than the ulna. The ulna is still ununited chiefly because of the absorption which has taken place about the beef-bone peg.

Fig. 14. Same case as in Figure 10. The beef-bone peg in the ulna has been removed and the defect filled with an osteal-periosteal transplant from the left tibia.

Fig. 15. Same case as in Figure 10; taken 22 months after first operation. The patient has been at work 9 months. This case more than any other influenced against beef-bone pegs, and in favor of osteal-periosteal transplants in case of marked loss of bone substance.

This case illustrates extremely well that periosteum will form new bone and will bridge across even a marked loss of substance in the shaft; that in these old cases with changes in the bone, characteristic of poor blood supply, the beef-bone peg can delay the healing process by causing bone absorption, and that a more or less thin piece of cortex attached to a wide strip of periosteum furnishes a better method of repair. The osteal portion of such a transplant can be made sufficiently thick to give substance and strength to the transplant, thus furnishing a certain amount of internal splinting. The wide strip of periosteum attached to this narrower osteal portion can be wrapped around the shaft of the bone to be repaired, thus furnishing more osteogenic tissue than is usually contained in the usual autogenous bone graft. While such a transplant may not have the finished mechanical touch of an autogenous graft cut by the twin saws, yet it can be removed more quickly by blunt dissection and with a chisel and mallet and will contain almost 3 times as much periosteum as the autogenous graft cut by the former method. In my hands, this method takes at least one-third less time than I consumed in cutting and fitting my autogenous grafts. While 14 months seems a long period for the repair of old ununited fractures, yet 1 case took 2 years before complete union occurred in a somewhat similar case in which an autogenous graft was used. But the above case illustrates the chief point I am endeavoring to make, viz., that the pure periosteal transplants did form new bone and in the case of the radius bridged across a bony defect of approximately 2 inches.

Case 5. R. Y., male, 18 years old, referred by Dr. C. O. Wiltfong, of Chesterton, Indiana, on October 2, 1925. This boy had suffered a fracture of the lower end of the shaft of the radius on August 31, 1922. After repeated efforts to secure reduction, it became necessary to resort to an open operation. The case was referred to another hospital in Chicago, September 6, 1922, and one of the surgeons operated, attaching a Lane plate to the shaft of the radius in order to hold the fragments in apposition. The boy made a good recovery from the operation and good union had apparently been secured by the end of 5 months. All splints were removed and he was allowed to use the arm freely. He had no trouble with the member until one day, 3 years and 9 months later, while playing in the school yard, he seemed to feel something give in this arm. He had no pain but shortly thereafter a slight swelling developed. Dr. Charles H. De Witt, of Valparaiso, Indiana, made an X-ray examination which showed that the Lane plate had loosened and there was either a new fracture or non-union at the site of the old fracture. A false point of motion

16 16 17 18 18 19 19

Fig. 16. Ununited fracture of radius of 3 years' duration. Operation: Lane plate removed; fragments adjusted; and strips of periosteum removed by blunt dissection from the proximal fragment and turned downward across the site of the fracture, forming a periosteal bridge chiefly along the lateral surface. First film was taken 1 week after operation.

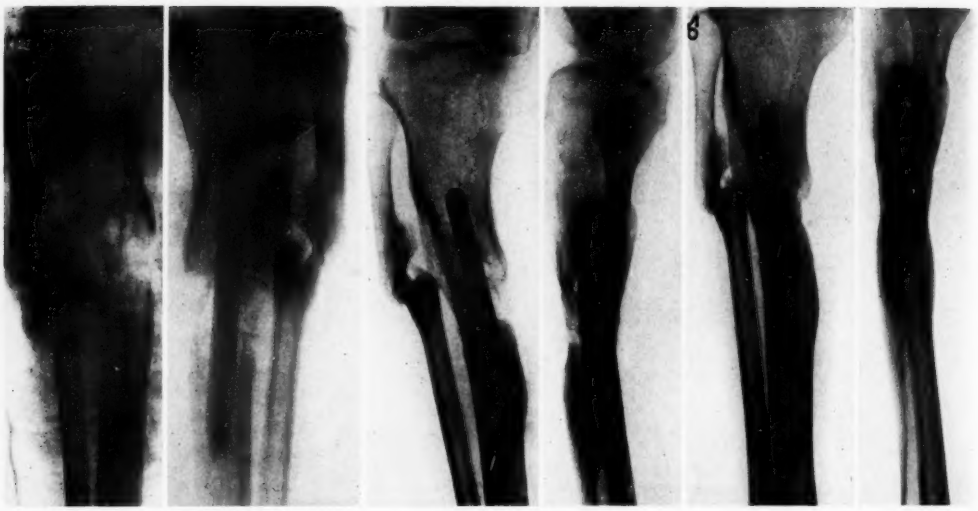
Fig. 17. Same case as in Figure 16, taken 16 days after operation. Note the growth of the periosteal transplant.

Fig. 18. Same case as in Figure 16; 2 months after operation. The periosteal transplant has fused with the shaft. Note that the regeneration of this bone is best at and near the transplant.

Fig. 19. Same case as in Figure 16, showing a green-stick fracture at this site 11 months after operation for ununited fracture. Note that the new bone along the lateral margin where the periosteal transplant was applied is the only portion of the shaft not refractured.

could be easily demonstrated. The case was brought on September 27, 1925, to Chicago, but as the original surgeon had moved to another city, the boy was entered on my service at St. Luke's Hospital. At operation, one of the screws from the Lane plate was found lying in the soft tissues and the other screws loosened up, so that the plate was easily removed. The fragments below the plate and about the site of the fracture were denuded of periosteum. The ends of the fragments were osteoporotic. This softened bone was removed, thereby freshening the ends of the fragments. They were in very good alignment and no effort to change the alignment was made. The shaft of the radius above the site of the fracture was exposed and a strip of periosteum was removed by blunt dissection and turned down across the site of the fracture. Great effort was made to secure an abundance of periosteum across this defect in the bone and some of the strips were therefore turned down so that the cambium layer pointed outward. The anterior surface of the bone alone was covered, however. Figures 16, 17, and 18 show the rapid healing which occurred in this old fracture. From the findings at the time of operation, this was definitely an ununited and not a recent fracture. The fracture had never united under the Lane plate. The boy was discharged 10 weeks after the operation with firm union.

Since writing the foregoing, we have had an extremely interesting additional observation in this case. On September 8, 1927, while playing ball, the patient fell, striking on his extended right hand. He immediately felt pain at the site of the old fracture and observed an angulation deformity. Swelling of the forearm rapidly followed. He was again taken to Dr. De Witt, of Valparaiso, Indiana, who examined the arm with the X-ray and diagnosed a fracture at the site of the old fracture. He was sent at once to my service at St. Luke's Hospital. Examination showed a slight angulation, slight swelling, and point of moderate tenderness directly over the site of the old ununited fracture described above. Study of the roentgenogram which he brought with him, and of a second film taken 3 weeks later (Fig. 19) showed the following: There is a line of fracture through approximately two-thirds of the shaft of the radius resembling a green-stick fracture. The unfractured portion of the radius consists of one-third of the lateral portion of the cortex where the periosteal transplant was placed across the site of the old fracture just 11 months previously. This unfractured portion shows strong, healthy bone but slightly bent. The margins of the fragments of the fractured portion and the shaft above and below this fracture, are somewhat osteoporotic and you can still see 2 drill holes used for the Lane plate 4 years ago. In other words, firm union of this old ununited fracture resulted along the anterior margin where the periosteal transplant was laid, but that portion of the shaft which was not covered by the transplant showed poor osteogenesis.



20 21 22 22 23 23

Fig. 20. Defect in shaft of tibia following injury in explosion 6 months previously.

Fig. 21. Same case as in Figure 20, 1 month after operation. Beef-bone peg used for internal splinting and defect in tibia bridged by 2 strips of pure periosteum, the first removed and turned downward from the proximal fragment and the second transplanted from the distal fragment. Both periosteal transplants show definite osteogenesis but best in the proximal transplant.

Fig. 22. Same case as in Figure 20, showing growth of transplants with bridging of the marked defect in the tibia.

Fig. 23. Same case as in Figure 20; taken 2 years after the periosteal transplant was made. The shaft of the tibia is practically reconstructed but a small sinus persisted which caused another surgeon to remove the beef-bone peg. A quicker result would have followed an osteal-periosteal transplant with fixation by external splinting.

This case, as well as Case 2 (Figs. 5 and 6), demonstrate conclusively that a pure periosteal transplant, containing no cortical bone substance whatsoever, will grow and form new bone. Study of these roentgenograms shows that this new bone involves the cortex immediately under the periosteal transplant; however, in the portion of the shaft not covered by the periosteal transplant, new bone did not grow, so that there was a partially ununited fracture of the shaft. I have not observed this condition in any of the other cases, yet these two cases enable us to arrive at the following conclusions:

1. The periosteal transplant will form new bone, but it may be limited only to that portion of the shaft covered by the transplant.

2. To insure complete union in an ununited fracture, at least two-thirds of the shaft at the site of fracture should be covered by the periosteal transplant.

3. More rapid and more complete healing of the ununited fracture will result if the shaft, at the site of the fracture, is completely surrounded by periosteal transplant.

Case 6. J. T., male, of Beloit, Wisconsin, 38 years of age. In March, 1923, this patient was in an explosion and suffered a severe compound fracture of the upper third of the right leg. The soft tissues were badly lacerated and a fragment approximately 3 inches long was blown from the shaft of the tibia at the junction of the middle and upper third. Considerable doubt existed as to whether the leg should be amputated. The writer was called to see the case a few days later and agreed with Dr. Benjamin Fosse that his treatment of debridement followed by the Carrel-Dakin method of irrigation was justified and might result in saving the limb. A very marked infection developed which persisted for weeks. Eight months elapsed before we felt it was safe to attempt repair of loss of bone substance in the tibia. Figure 20 shows the condition of the tibia at that time.

On April 23, 1924, the author went to Beloit and operated upon this case with Dr. Fosse. Operation consisted of freshening the upper fragment of the tibia and of cutting away the osteosclerotic portion of the lower fragment of the tibia. This left a gap of approximately 2½ inches to be filled in. A discharging sinus still persisted from the wound in the

24 24 25 25 26 26

Fig. 24. Unreduced, comminuted fracture of the tibia and fibula operated upon 5 weeks after injury. Operation: fracture reduced and held in alignment by beef-bone peg, intramedullary splint; the fracture site then covered by periosteal transplant removed and turned downward from the proximal fragment of the tibia.

Fig. 25. Same case as in Figure 24, showing the repair of the fracture and almost complete absorption of the beef-bone peg 5 months after operation.

Fig. 26. Same case as in Figure 24; taken 10 months after operation. Patient has been working for 5 months; complete restoration of function.

soft tissues and therefore a complete removal of old infected tissue in the neighborhood of the fracture was made at this time. A beef-bone peg was inserted in the medullary canal of the lower fragment of the tibia and worked upward into the medullary canal of the upper fragment, thus forming an internal splint which held the tibia in proper alignment. Next, a strip of periosteum 3 inches long and the entire width of the upper fragment of the tibia was removed by blunt dissection downward but left attached at its lower margin and turned as on a hinge downward over the defect in the tibia. Strips of periosteum were next removed from the anterior surface of the lower fragment of the tibia and were laid across the defect. Soft tissues were closed over the defect as well as possible, but complete closure could not be secured because of the amount of tissue which it was necessary to dissect away because of the old infection.

Patient made a slow but progressive recovery and the growth of new bone from these periosteal strips is well illustrated in Figures 20, 21, 22, and 23. The soft tissues closed over the area except for one small persistent sinus. Solid union had occurred in this case by January, 1926—1 year and 8 months after the operation. At this time the sinus would remain closed for a few weeks and then would open but with very little discharge. Since the patient was at work and was getting along very well, it was my judgment that this condition should be left alone for at least 6 months more, fearing a recurrence of the infection if another operation was attempted too soon. In June, 1926, however, I was called in consultation on this case by the insurance company, with another surgeon of Chicago. This surgeon felt that the case should be re-operated upon at once and the beef-bone peg removed. A week later I was told that this surgeon had removed the beef-bone peg. I have learned that the old fracture showed good union but that the beef-bone peg was lying loose in the medullary canal, with softening of the bone immediately in the neighborhood of the peg. His operation consisted simply of removal of the peg and curetting away the soft portion of bone in the neighborhood of the peg. The wound healed and the patient was discharged from the hospital in 4 weeks. Patient now has good, firm union without any evidence of infection and approximately 75 per cent of function in the knee joint.

Observation of a series of 25 X-ray films taken on this case, from 3 weeks after my beef-bone internal splinting periosteal transplantation to June, 1926, a little more than 2 years after the operation, again demonstrates that periosteum will grow and form new bone.

If I were operating upon this case today, instead of using the beef-bone peg, I would use an osteal-periosteal transplant, as described under Case 4. This case, however, does illustrate that the restoration of periosteum across the marked defect in this tibia resulted in regeneration of bone and closing in of the defect. It is my judgment that the defect closed more rapidly than would have been the case if I had used a narrow autogenous bone graft containing only a small amount of periosteum. Further, the cutting

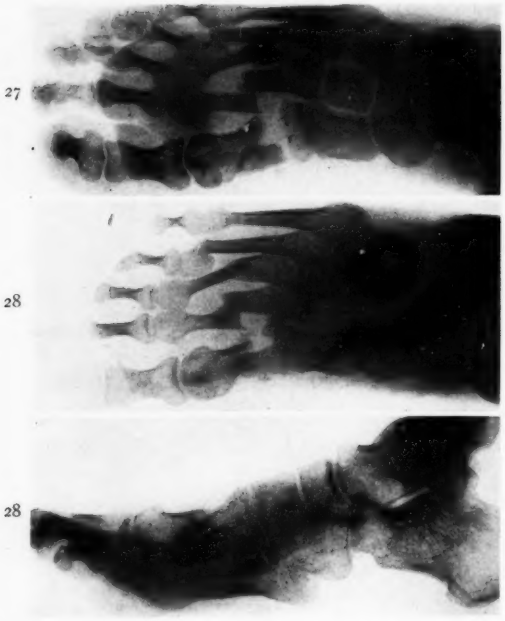


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Fig. 27. Defect in the first metatarsal after the proximal fragment was removed because of deformity and non-union. The defect has just been bridged with a pure periosteal transplant from the tibia.

Fig. 28. Same case as in Figure 27, showing reconstruction of defect in metatarsal, by growth of periosteal transplant, 7 weeks after operation.

of such bone graft in an area where infection had been rampant a few months before, would have made recurrence of the infection more probable.

CASE 7. D. B., male, 45 years old, referred to my service at St. Luke's Hospital by Dr. Noble, Harvey, Illinois, on November 12, 1925, because of an unreduced fracture of the left tibia and fibula just below the middle third. The injury occurred on October 9, 1925, and every effort had been made to secure union by the closed method. At operation I found a thick fibrous band between the fragments of the tibia composed of interposing soft tissue and fibrous tissue, characteristic of non-union. This was cut away and the ends of the fragments freshened. The alignment and apposition was made by an intramedullary beef-bone peg used as a bone splint. A periosteal transplant was then removed from the upper portion of the shaft of the tibia, consisting of the width of the tibia and about 4 inches in length, and was carefully wrapped and sutured about the site of fracture. Figures 24, 25, and 26 show the subsequent development of bone and union of the fracture in this case.

29 29 30 30 31

Fig. 29. United fractures of radius and ulna of 8 months' duration.

Fig. 30. Same case as in Figure 29, taken 3 weeks following operation, August 12, 1927. Operation: alignment of fragments; pure periosteal transplants from the tibia wrapped about the site of fractures; wounds packed and plaster-of-Paris splint applied direct to skin; operative field again made sterile, packing removed from the wounds and fragments readjusted and held until the splint hardened; wounds then closed. Note the growth of the periosteal transplant on the ulna.

Fig. 31. Same case as in Figure 29. October 7, 1927. Showing the growth of the transplants and union is almost complete.

Six of the cases in which periosteal transplants have been used have been in old fractures of the tibia. In all but 2 of these I have been able to notch the upper fragment and sharpen the lower fragment in such a way that it fitted into the notch, thus giving apposition and a certain amount of fixation without using any foreign material for fixation. The method of external fixation by splinting and by circular bands of plaster of Paris described at the end of this article has obviated the need of internal splinting in the majority of my cases. In 1 of these cases the defect was covered by periosteum secured from the adjacent shaft and fixation secured by 2 Putti bands which were later removed. Whenever Putti or Parham-Martin bands are used, great care should be exercised to see that these are applied around the bone outside of the periosteum, and not next to the bone denuded of periosteum. In another case in which internal fixation was necessary, I chiseled a narrow, rather thick piece of cortex from the adjacent shaft to which was attached wider portions of pure periosteum. This

osteal portion formed the internal splint while periosteum furnished the osteogenic tissue.

CASE 8. F. F., male, 30 years of age, referred on January 17, 1927, for reconstructive operation on his foot. Eight months previously he had suffered a fracture of the first, second and third metatarsals of the right foot. These had united, but patient complained of severe pain in the sole of his foot when walking or standing. Examination showed the proximal portion of the first metatarsal was displaced backward and into the sole of the foot. Pain was undoubtedly due to pressure on this displaced proximal fragment. At operation, incomplete union of this fracture was found. The proximal fragment was so badly displaced that the deformity could be overcome only by complete removal of this fragment. The removal of this left the joint surface of the scaphoid bone exposed with a gap of approximately 2 inches between it and the distal fragment of the first metatarsal. A periosteal transplant was removed from the right tibia with a small piece of fascia attached to its outer margin. This fascia was sutured to the soft tissue so that it formed a septum or curtain over the joint surface of the scaphoid. The periosteum was rolled into a tube and sutured to the periosteum of the distal fragment and to the soft tissues in the sole of the foot, thus forming a pure periosteal transplant across the defect in this metatarsal. Figures 27 and 28 show the rapid development of new bone which filled in the defect and resulted in a complete cure in this case.

CASE 9. G. W., female, 35 years of age, operated upon at Gary, Indiana, with Dr. Ira Miltimore on July 15, 1927, had suffered fracture of both bones of the forearm, middle third, some 8 months previously. Several attempts at reduction were made and fair alignment of the fragments was finally attained. The fragments were immobilized with mechanical rather than plaster splint and immobilization was very imperfect. At the end of 6 months, the case was referred to Dr. Miltimore. He attempted by closed reduction and immobilization to secure union and by the end of 2 months, it was evident that permanent non-union existed. At operation the sites of fractures were exposed by two incisions, the ends of the fragments freshened and attempt to wedge them together by notching made. No internal splint was used. The absence of all periosteum about fractured fragments was definitely noted. A large strip of pure periosteum was then removed by blunt dissection from the right tibia and this was divided equally into two parts, one portion of periosteum was wrapped approximately one-half way around the shaft of the radius, and the other portion about the shaft of the ulna at the site of the fractures. The wounds were then packed and a plaster splint with circular bands of plaster-of-Paris bandages applied for external splinting, as described below. Sterile gloves and gowns were then again put on by the operator and his assistant, the splint in the neighborhood of the wounds carefully covered by sterile towels and the packing then removed from the wounds for inspection. Slight adjustment was necessary to secure fair anatomical alignment of the fragments, soft tissues and skin was then closed. This patient now has union of both fractures (November 1, 1927). Figures 29, 30, and 31 show the growth of the periosteal transplants.

INTERNAL VERSUS EXTERNAL SPLINTING

Before granting the value or superiority of such a transplant as this thin, soft periosteal tissue, the question of fixation and alignment of the fractured fragments must be met. If we will acknowledge that the periosteum on a complete bone graft is the chief osteogenic layer of the graft, then the chief function of the cortex or firm bone of the transplant is to act as an internal splint, to bridge across the defect holding the two ends fixed and in alignment. In the majority of cases this cortex splint must be held in close approximation and fixation to its host by some foreign material such as chromic catgut or kangaroo gut, autogenous or ivory peg, wire, etc. Groves seems to favor a peg or wire, as firm fixation is of prime importance, and he states that when a peg is used, dead bone is of equal value to an autogenous bone peg.

Since foreign material must be included so frequently with the autogenous bone graft, then why should we not resort to some form of foreign material as a means of internal splinting and fixation of the bone fragments combined with the easier obtained and far superior large periosteal grafts. In many cases the fragments can be held in approximation and fixation by the use of external plaster-of-Paris splint with plaster-of-Paris encircling cast above and below the defect or the fragments can be impacted after freshening or even held by kangaroo gut and then the defect wrapped with the periosteal graft. But when this is impossible or there is a considerable loss of bone substance to be bridged, then either a cortical graft must be used or a foreign material substitute employed.

Following the above reasoning, I began the use of beef-bone pegs as a means of internal splinting, when necessary, some 4 years ago. Recognizing that the round, beef-bone peg, filling the entire medullary

canal, frequently resulted in absorption of the cortex adjacent to the peg, I had made a triangular beef-bone peg which came into contact with the medullary canal at only 3 points. This peg has absorbed more rapidly than the round peg and has caused less bone absorption. A number of methods have been devised for pushing or pulling the round beef-bone peg from the intramedullary canal of one of the fragments downward or upward into the medullary canal of the adjacent fragment. The method usually used is that of chiseling a small window in the shaft of the upper fragment, inserting a pair of artery forceps and grasping a suture threaded through the end of the beef-bone peg already inserted in the opposite medullary canal. Traction upon this suture then pulls the peg upward or downward into the adjacent canal. This technique adds considerably to the length of the operation. To overcome this objection I had the triangular beef-bone peg notched. A small spatula could then be slipped between the approximated fragments, grasping these notches each in turn and shoving the peg upward or downward into the adjacent canal. This overcomes most of the difficulties of inserting a beef-bone peg.

Years ago I gave up the use of Lane plates, of wire, and of other metallic material as a means of internal fixation, due to three facts: first, the presence of these metallic substances frequently resulted in bone absorption; second, it was frequently necessary to remove them; third, in the majority of cases some better method of fixation could be secured. The same objections can be applied to the use of the circular beef-bone peg and also to the triangular peg. I have been forced to remove two beef-bone pegs, and another surgeon has removed one of the pegs that I have inserted, and careful observation of the X-ray reproductions in this article show that in a few cases bone absorption has occurred. Therefore, I am less and less prone to use any method of internal fixation, except the osteal-periosteal graft, when there is considerable bone defect. In all other cases I have found external splinting sufficient.

In all cases of open reduction of fractures or of operation on old ununited fractures, I am now using the following plan of external splinting: After the operation is completed on the bone proper and before the soft tissues are closed over the repaired fracture, the wound is carefully packed and protected from contamination. While this is being done an assistant is molding a plaster-of-Paris splint of the desired length for the extremity. One layer of thin sheet wadding or often no padding at all is used. The splint is then applied directly to the limb opposite the operative wound. The splint is fixed to the extremity by a few turns of a circular plaster-of-Paris bandage applied, in the case of a leg, first about the thigh, then just below the knee above the site of the operative wound. Another circular plaster-of-Paris-bandage is thrown around the splint and lower extremity just below the operative wound. Only one or two turns of this plaster bandage is applied below at this time. During the application of this splint and circular bandage, an assistant has held the extremity in proper position to maintain the apposition and alignment of the fragments. The operator and one assistant now put on fresh sterile gowns and sterile gloves; clean linen is put under and over the extremity and sterile towels are packed carefully into the margins of the splint so that the packing in the operative wound can now be removed, leaving the operative field sterile. The repaired site of fracture is carefully inspected and any slight readjustment of the fragments that is necessary, is made. This can all be done before the splint has become too hard for slight readjustments. By actual inspection the operator now knows that he has his fragments properly aligned, and while the assistant holds the extremity until the splint becomes hard, the soft tissues and skin can be closed by the operator. The splint can now be strengthened by further plaster-of-Paris bandages.

This patient can be returned to his bed and X-ray pictures taken the next day, and in every case thus far the fragments have been in exactly the position arranged at the operation. This inspection method is so simple that one wonders why we have always closed our wounds in the past and then

applied our circular casts or splints, constantly dreading that the fragments would slip and often finding, when the X-ray picture is taken, that they have slipped, necessitating further operation or manipulation.

CONCLUSIONS

1. The consensus of opinion of practically all investigators on the subject of "How Does Bone Grow?" indicates that periosteum of all the three bone layers contains the chief osteogenesis.

2. Pure periosteal transplants, containing no cortical substance whatsoever, in the cases herein reported, have resulted in union of fractures in delayed union, in repair of ununited fractures and in bridging across large bony defects. Studies of the serial X-ray pictures in each case show the new bone formation starts and continues from the transplanted periosteum.

3. Experience in this method has taught that best results are obtained the more completely the shaft at the site of the fracture is covered by the periosteal transplant. In the neighborhood of these old fractures, especially with non-union, the adjacent fragments are practically always completely denuded of periosteum. Therefore, the aim of this transplant is to replace as nearly as possible this osteogenic layer.

4. External splinting as a method of holding the fragments in alignment is far superior to any method of internal splinting or fixation by means of foreign material such as Lane plates, wire, beef-bone pegs, etc.

5. When there is considerable bony defect which must be bridged, the autogenous graft or better the osteal-periosteal transplant is probably superior to the pure periosteal transplant.

6. Whichever method, bone graft, osteal-periosteal or pure periosteal transplant, is used, more rapid and better results will be obtained if a large piece of periosteum is employed to surround most of the shaft at the site of the defect.

7. In practically every case in which an autogenous bone graft is indicated, the same repair can be obtained, more rapidly and with less trauma to the tissues, by the use of an osteal-periosteal or pure periosteal transplant.

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EXPERIMENTAL STUDY OF THE FACTOR OF BILIARY STASIS IN THE PRODUCTION OF GALL STONES[1]

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AND
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STASIS of bile in the biliary tract has long been considered a predisposing and exciting cause of gall stones. Attention has recently been called anew to this factor by the experimental work of Whitaker,[2] who has produced gall stones in cats by the stagnation of bile alone. To induce stasis of bile in the gall bladder, he cut and dilated the sphincter of the common bile duct of the cat, a procedure which has been shown to prevent refilling of the gall bladder. Nine hours afterward the cat was given a fat meal to cause partial emptying of the gall bladder, and was then starved for several days, when autopsy showed a "stone," apparently a cast of the shrunken gall bladder.

Production of stones in the gall bladder by stasis alone seemed so striking that we have repeated and extended the experiments of Whitaker. His technique for the production of stasis by cutting the sphincter was carried out on 18 cats. In many of the experiments described by Whitaker, iodized oil was introduced into the gall bladder to demonstrate the stasis of bile. To eliminate this factor, which we thought might play some part in the process described by Whitaker, the iodized oil was injected into the gall bladders of only 7 of the 18 cats. In the gall bladders of the 11 cats in which stasis had been produced but no iodized oil injected, there was not the slightest trace of the formation of stone. Six dogs, similarly treated, likewise, did not show stones. Of the 7 cats in which iodized oil was injected into the gall bladder, 3 had semi-solid masses resembling the stones described by Whitaker. As iodized oil seemed to be the deciding factor in the production of these masses, another series of experiments was performed in which no stasis was produced. Iodized oil was merely injected into the normal gall bladder. Similar masses were sometimes found in these gall bladders, although no stasis was present. These experiments seem to indicate clearly that the iodized oil rather than stasis was the important factor in the production of the so-called "gall stones."

The semi-solid masses which were produced in the gall bladders containing lipiodol seemed to be similar to those described by Whitaker. These masses have little resemblance to human gall stones. They are greenish black, soft, and homogeneous, varying in size, sometimes occupying the entire gall bladder. Examination shows the presence of fat globules in the specimens. We were inclined to think at first that soaps were present but chemical examination did not confirm this. Cholesterol was not found, which again strongly suggests that they bear little relation to human gall stones, but instead result directly from the presence of iodized oil.

Believing, nevertheless, in spite of our negative experiments, that stasis is undoubtedly one factor in the production of gall stones in man, we performed experiments in which stasis of the bile was associated with another important factor, infection. Stasis of bile was produced in cats after the method of Whitaker, by cutting the sphincter of the common bile duct. Stasis was produced in dogs by another method which insured complete stagnation in the gall bladder and yet did not cause obstructive jaundice. This is made possible by the anatomical arrangement of the ducts in the dog. Two lateral hepatic ducts join the common bile duct at a considerably lower level than the junction of the middle hepatic and cystic ducts. The common bile duct can, therefore, be ligated in its upper part, so that the middle hepatic duct drains only into the gall bladder, from which emptying is prevented by the ligature. This technique insures complete stasis in the gall blad-

[2] Whitaker, L. R. The mechanism of the gall bladder and its relation to cholelithiasis. J. Am. M. Ass, 1927, lxxxviii, 1542.

[1] From the Department of Surgery, Washington University Medical School, and Barnes Hospital.

der and at the same time maximum concentration of bile.

Simultaneously with the production of stasis by these methods in cats and dogs, organisms were introduced into the gall bladder, bacillus coli, staphylococci, and streptococci being used. The animals were sacrificed after periods varying from a few days to several weeks. Neither cholelithiasis nor chronic cholecystitis was thereby produced in any instance.

Experiments were then performed in which substances which might serve as nuclei for stone formation were placed within the gall bladder, where stasis of bile had been induced. In some instances, infection of the bile was added. Tissues of parenchymatous organs, fragments of metal, gauze, calcium lactate, cholesterol, lecithin, and colloidal substances were used. No stones were formed under any of these conditions. In one cat, however, in which a piece of gauze, infected with bacillus coli, was inserted into the gall bladder, a marked degree of chronic cholecystitis resulted.

In another group of cats, the sphincter of the common bile duct was cut and the walls of the gall bladders, in some instances the mucosa and in others the serosa, were thoroughly cauterized with phenol. Autopsy of the animals after varying lengths of time did not reveal any stones.

As another point against the importance of stasis as the sole factor in the production of stones is the fact that those individuals whose bodily constitutions are associated with the greatest amount of stasis in the gall bladder, namely the visceroptotics, are not so likely to have stones as the short obese type. This point is elaborated in a paper by Sherwood Moore now in press.

SUMMARY

Clinical opinion has suggested the importance of stasis of bile, infection and the presence of nuclei in the gall bladder as factors in the production of gall stones in the human. We have not been able, however, to induce cholelithiasis in experimental animals by either stasis alone or by stasis combined with infection of the bile, even in the presence of various foreign bodies. Obviously, other conditions seem necessary for gall-stone formation. A likely factor may be intramural infection, especially since clinical investigation by one of us[1] has shown its frequent presence in cholelithiasis even when the bile is sterile.

[1] Illingworth, C. F. W. Types of gall-bladder infection. Brit. J. Surg., 1927, xv, 221.

FACTORS INFLUENCING PROGNOSIS IN CARCINOMA OF THE RECTUM[1]

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INFLUENCES which favor or prejudice the successful outcome of the surgical treatment of rectal or rectosigmoidal carcinomata, readily divide themselves into two groups—extrinsic and intrinsic. The extrinsic are modifying influences such as age, general condition of the patient, duration of the lesion with its attendant signs and symptoms, and various local conditions associated with the neoplasm, such as its size, situation, and mobility, the presence or absence of metastasis, both lymphatic and visceral, fibrosis, lymphocytic infiltration, and hyalinization. The intrinsic influence, with its attendant effect on extrinsic influence, is represented by the activity of the cancer cells themselves. From the surgical standpoint, extrinsic factors, except such elements as age and such general evidences of resistance as the extent of local resistance expressed in terms of fibrosis and so forth, determine the so-called "operability" of each case. This controversial appellation implies conditions favorable and unfavorable to the removal of cancerous growths: conditions which in borderline cases, must be measured and evaluated by the judgment, experience, and courage of the surgeon.

Nowhere is there any dissension from the dictum that metastasis to the liver rules out radical resection except in the small group of cases in which removal of the growth with restoration of the lumen of the bowel seems advantageous as a palliative measure.

Fortunately, one may resect portions of the prostate gland or seminal vesicle or perform hysterectomy in the course of an operation for extirpation of rectal carcinoma, with relatively satisfactory mortality, in certain selected cases. Whether or not the high mortality and morbidity and end-results in this particular group of cases warrant radical operation is extremely questionable, and one wonders (considering the fact that many patients suffering from inoperable carcinoma of the rectum, who have been subjected to palliative colostomy, enjoy a relatively satisfactory existence for 1 or 2 years) whether extensive technical feats, which unquestionably produce prolonged disability, are compatible with sound judgment. Occasionally, one of these extremely radical operations is followed by prolonged freedom from recurrence and encourages the practice of attempting to remove large, fixed carcinomata, but if the sacrifice of important organs is necessary in the course of the operation, more often than not such feats result in high immediate mortality and early recurrence. In the light of comparative results with other therapeutic agents, however, the suppression of carcinoma calls for extension in the scope of operability.

Undoubtedly, the best prognosis in the surgical treatment of rectal carcinoma attends that very favorable group of cases in which operation may be performed early, and in which the growth is not fixed, has not involved the lymphatics, and is found on resection not to have invaded the musculature of the colon. In this group of cases the operative mortality is extremely low for any type of resection and the percentage of cures is very high. We have not grouped our cases as favorable and unfavorable but, taking the cases which have been subjected to resection as a routine, we find that in approximately half of them there has been no recurrence at the end of 3 years, and in a third the patient is alive and free from recurrence at the end of 5 years. The operative mortality in the whole group for the double operation of colostomy and posterior resection was approximately 6 per cent.

Our rule in cases in which metastasis to the liver has not occurred is to attempt the resection of the offending growth in every case if it is not wholly immobile from fixation to adjacent organs

Fortunately, metastasis is a slow process and even lymphatic involvement does not take place rapidly. The first recurrence after operation is usually noted in the liver. Death

[1] Read before the Southern Surgical Association, Augusta, Georgia, December 13 to 15, 1927.

TABLE I.—GRADE OF MALIGNANCY AND METASTASIS AT OPERATION

	Grade 1	Grade 2	Grade 3	Grade 4	All grades
Patients with metastasis	22 (26.82% of 82)	128 (44.13% of 290)	77 (56.20% of 137)	33 (64.70% of 51)	260 (46.42% of 560)
Patients without metastasis	60 (73.17% of 82)	162 (55.82% of 290)	60 (43.79% of 137)	18 (35.29% of 51)	300 (53.57% of 560)
Lymph nodes examined	82	290	137	51	
Lymph nodes not removed*	23	9	4	2	
Total	105 (17.55% of 598)	299 (50.00% of 593)	141 (23.57% of 598)	53 (8.86% of 598)	

*One-stage type of operation as Quenu-Tuttle or Harrison-Cripps.

from metastasis to the liver is painless, in the majority of instances, in marked contrast to the long-drawn-out suffering which accompanies ulcerating, adherent, and inoperable growths. Sepsis from these huge foul surfaces, rather than metastasis, is the cause of death. Local fixation unquestionably is the cause of refusal of radical operation more frequently than internal metastasis.

The inadvisability of excluding the possibility of metastasis is evidenced by the fact that many times one feels that the hard lymph nodes in the immediate vicinity of the growth are an evidence of extension of the carcinoma. However, this may frequently be proved erroneous by microscopic examination and it is unwise to assume from palpation that all lymph nodes are cancerous; many nodes will be found on more careful examination to be inflammatory and the possibility of radical operation will not be excluded.

The duration of the growth and its situation influence the surgical outlook enormously. It is a difficult problem to fix the exact duration of symptoms and signs in a case of rectal carcinoma, since at the time the patient appears for treatment, symptoms and signs have been present for many months and, not infrequently, for years. In the average case of rectal carcinoma observed at the Mayo Clinic, symptoms have been present for more than a year. Since the signs and symptoms always consist of blood in the stools, change in bowel habits, or some obstructive phenomena, the growth must have progressed to the point of ulceration or, occasionally, to subacute obstruction before the patient is aware of its presence. The type of growth influences the duration of symptoms and signs depending on whether it is a rapidly progressing, cellular carcinoma or a more slowly growing type.

The situation of the growth is of importance from the standpoint of prognosis because the pathological types vary in different parts of the rectum, and, because of the influence on the time at which symptoms and signs appear. Most growths in the rectum occur in its ampullary portion or higher at the rectosigmoidal juncture. The smallest percentage of growths are in the anal canal and around the external anal orifice. The latter growths are usually epitheliomata and can always be recognized by the most superficial general examination; it seems entirely reasonable that they should be observed in their earliest stages. On the contrary, however, many cases of several years' duration are on record. The lymphatic drainage in this area is forward into the groin rather than retroperitoneal and lateral, as it would be were the growth higher, but in any event, once the lymph nodes in the groin are involved, radical operation is useless and the prognosis is hopeless.

Rectosigmoidal growths are not readily felt by the examining finger, but occasionally they telescope themselves into the ampulla of the rectum and may be palpated easily. The difficulty of determining the exact situation of the growths by proctoscopic examination is demonstrated in this class of cases in which operation sometimes reveals the growths at or above the rectosigmoidal juncture although they have been observed physically well down in the middle of the rectum. In women, growths in this situation are usually palpable through the vagina, particularly if fixation has occurred, since the tendency of a growth in the lower part of the sigmoid is to drop down into the cul-de-sac and fasten itself onto the

TABLE II.—GRADE OF MALIGNANCY AND RESULT OF OPERATION[1]

	Grade 1	Grade 2	Grade 3	Grade 4	All grades
Information	103 (98.09% of 105)	293 (97.99% of 299)	139 (98.58% of 141)	52 (98.11% of 53)	
Living	58 (56.31% of 103)	112 (38.22% of 293)	35 (25.17% of 139)	8 (15.38% of 52)	
Good result*	55 (94.82% of 58)	101 (90.17% of 112)	33 (94.28% of 35)	7 (87.50% of 8)	
Poor result†	3 (5.17% of 58)	11 (9.82% of 112)	2 (5.71% of 35)	1 (12.50% of 8)	
Dead	45 (43.68% of 103)	181 (61.77% of 293)	104 (74.82% of 139)	45 (86.53% of 52)	
Good result‡	4 (13.79% of 29)	13 (8.38% of 155)		2 (5.40% of 37)	
Poor result**	25 (86.20% of 29)	142 (91.61% of 155)	87 (100% of 87)	35 (94.59% of 37)	
Total good result	59 (67.81% of 87)	114 (42.69% of 267)	33 (27.04% of 122)	9 (20.00% of 45)	215 (41.26% of 521)
Total poor result	28 (32.18% of 87)	153 (57.30% of 267)	89 (72.95% of 122)	36 (80.00% of 45)	306 (58.73% of 521)

[1]This table does not include cases in which death occurred after operation or in the hospital, or after the patient was dismissed if the interval after the operation was too short to determine whether or not the patient would have died from the carcinoma; nor does it include cases in which the cause of subsequent death is unknown.

*This indicates that the patient had been free from carcinoma, as far as could be ascertained, for a number of years, the average of which can be found in Table VI.

†This refers to cases in which there had been one or more recurrences and progress was not favorable when the patient last reported. The average interval since operation can also be found in Table VI.

‡This signifies that the patient lived for a number of years without recurrence and finally died from causes unrelated to the carcinoma (apoplexy, pneumonia, etc.). A few cases are also included in which after at least a year, without recurrence, the patient died from some other disease and necropsy examination showed no evidence of carcinoma in the body.

**This refers to cases in which there was reason to believe that death was due to the carcinoma even in the face of the fact that in some instances death did not occur until more than 7 years after operation had been performed.

posterior wall of the uterus. Rectosigmoidal growths require an abdominal type of operation which is a more formidable procedure than posterior resection following colostomy; and yet, because of their early obstructive signs, they should be recognized in an earlier stage than the lower growths of the rectum proper. By using a graded operation which consists of colostomy and an anterior type of resection, one of us (Rankin) has removed the rectosigmoid and rectum, down to the anal canal, in a series of 23 consecutive cases with but 1 death. This reduction in mortality has been due to several factors, the most essential of which are adequate pre-operative preparation and the use of spinal anæsthesia. The operation permits wide removal of the lymphatic structures and the remote results should be satisfactory. If the growth is situated in the middle or upper portion of the rectum, extirpation by either the graded operation of colostomy and posterior resection, or the abdominoperineal type of procedure, as advocated by Jones or Miles, may be carried out with low mortality and satisfactory end-results.

Age is another factor which influences prognosis most emphatically. Fortunately the average age in cases of carcinoma of the rectum is more than 50 years. Most of the patients at the Mayo Clinic have been between the ages of 45 and 60 and most satisfactory end-results have been obtained by radical operation on the elderly patients. There is ample clinical evidence to the effect that the prognosis in rectal carcinoma in the earlier decades is highly unfavorable. Unfortunately, there are a great many cases of carcinoma of the rectum in patients between the ages of 20 and 30 and even below 20. The active tissues

TABLE III.—METASTASIS, GRADE OF MALIGNANCY, AND RESULTS

	Grade 1	Grade 2	Grade 3	Grade 4	All grades
Patients with metastasis	22 (8.46% of 260)	128 (49.23% of 260)	77 (29.61% of 260)	33 (12.69% of 260)	
Information	22 (100% of 22)	127 (99.21% of 128)	77 (100% of 77)	33 (100% of 33)	
Living	7 (31.81% of 22)	36 (28.34% of 127)	11 (14.28% of 77)	1 (3.03% of 33)	
Good result	7 (100% of 7)	29 (80.55% of 36)	10 (90.90% of 11)		
Poor result		7 (19.44% of 36)	1 (9.09% of 11)	1 (100% of 1)	
Dead	15 (68.18% of 22)	91 (71.65% of 127)	66 (85.71% of 77)	32 (96.96% of 33)	
Good result	1 (9.09% of 11)	1 (1.23% of 81)			
Poor result	10 (90.90% of 11)	80 (98.76% of 81)	59 (100% of 59)	26 (100% of 26)	
Total good result	8 (44.44% of 18)	30 (25.64% of 117)	10 (14.28% of 70)		48 (20.68% of 232)
Total poor result	10 (55.55% of 18)	87 (74.35% of 117)	60 (85.71% of 70)	27 (100% of 27)	184 (79.31% of 232)

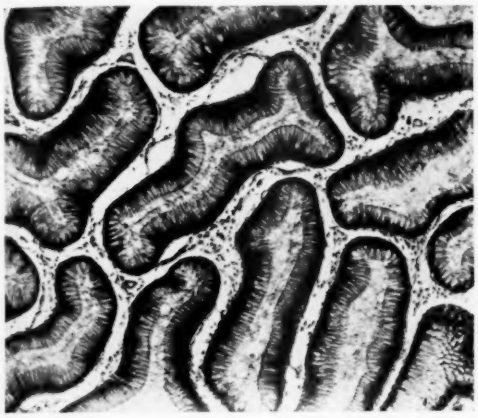

Fig. 1. Adenoma in which the cells are practically completely differentiated; for this reason it is called benign.

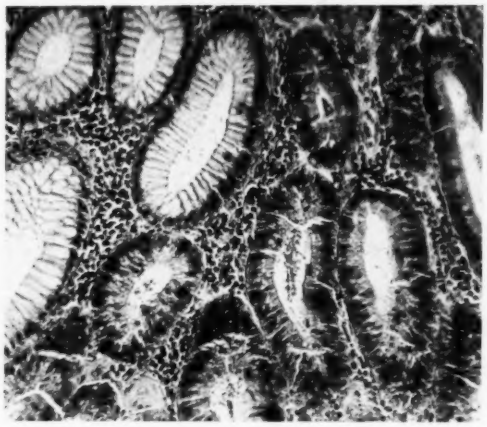

Fig. 2. Adenocarcinoma, graded 1, in an adenoma. The cells in the acini in the upper left-hand corner are practically completely differentiated while those in the acini in the right and lower part of the section are not; the latter are therefore cancerous.

of youth, instead of resisting cancer invasion, invite its spread and the young person who is host to a malignant neoplasm has little chance for longevity, regardless of the type of therapeutic measures instituted. The lymphatic senescence and tissue inactivity, common to advancing years, offer a much more satisfactory first line of defense than the vital elasticity of youth.

PATHOLOGY

Carcinoma of the rectum, like carcinoma of other parts of the gastro-intestinal tract, is usually of the adenomatous or gland type; occasionally a squamous-cell epithelioma or epidermoid carcinoma is found but it is usually situated at the anus. When a squamous-cell epithelioma is found above the anus, its origin is explained in the same way as that of epithelioma of the stomach and gall bladder: the regenerative cells of the glandular epithelium in these organs have the power to produce either a secretory (glandular) epithelium or a protective (squamous) epithelium. In this series of cases there was also one melano-epithelioma situated just inside the anus; this is rare in the rectum. Adenocarcinoma of the rectum, like carcinoma of other parts of the intestinal tract, presents different gross forms: papillary, polypoid, mucoid, ulcerating, infiltrating, napkin-ring, and so forth. It is also liable to infection and degenerative processes as well as to ulceration. Microscopically the cells of adenocarcinoma of the rectum may be

TABLE IV.—ABSENCE OF METASTASIS, GRADE OF MALIGNANCY, AND RESULTS

	Grade 1	Grade 2	Grade 3	Grade 4	All grades
Patients without metastasis	60 (20.00% of 300)	162 (54.00% of 300)	60 (20.00% of 300)	18 (6.00% of 300)	
Information	58 (96.66% of 60)	158 (97.53% of 162)	58 (96.66% of 60)	17 (94.44% of 18)	
Living	32 (55.17% of 58)	74 (46.83% of 158)	24 (41.37% of 58)	6 (35.29% of 17)	
Good result	30 (93.75% of 32)	72 (97.29% of 74)	23 (95.83% of 24)	6 (100% of 6)	
Poor result	2 (6.25% of 32)	2 (2.70% of 74)	1 (4.16% of 24)		
Dead	26 (44.82% of 58)	84 (53.16% of 158)	34 (59.64% of 57)	11 (64.70% of 17)	
Good result	2 (13.33% of 15)	12 (17.64% of 68)		2 (18.18% of 11)	
Poor result	13 (86.66% of 15)	56 (82.35% of 68)	24 (100% of 24)	9 (81.81% of 11)	
Total good result	32 (68.08% of 47)	84 (59.15% of 142)	23 (47.91% of 48)	8 (47.05% of 17)	147 (57.87% of 254)
Total poor result	15 (31.91% of 47)	58 (40.84% of 142)	25 (52.08% of 48)	9 (52.94% of 17)	107 (42.12% of 254)

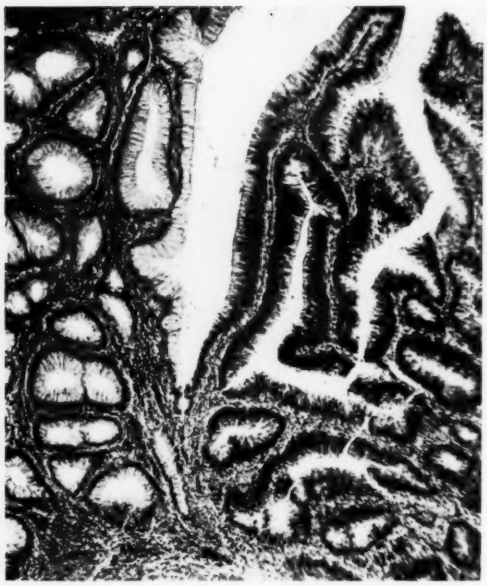

Fig. 3. Adenocarcinoma, graded 1, in right half of section and benign adenoma in left half. The right side of the crypt is malignant and the left half is benign.

Fig. 4. Adenocarcinoma, graded 2. The cells in the acini are not as well differentiated as in the two previous illustrations, and the acini are not as well formed.

differentiated to such a marked degree and arranged in glandular or acinous formation with such good cell alignment that they appear almost like normal rectal mucous glands; a number of these cells even secrete mucus that is indistinguishable from the mucus secreted by a benign adenoma. As a matter of fact a number of carcinomata of the rectum of low-grade malignancy originate in adenomata. Furthermore, contrary to the prevailing opinion, Saint has shown that the change from a benign adenoma to a carcinoma takes place more often at the periphery than at the base. Mitotic figures may or may not be numerous in these carcinomata showing advanced differentiation but they are usually regular in form. On the other hand, carcinomata of the rectum may be so undifferentiated that practically all traces of gland formation are lost. The cell nuclei are usually large, irregularly roundish, and deeply staining and as a whole the cells have lost their columnar form.

TABLE V.—NO LYMPH NODES REMOVED, GRADE OF MALIGNANCY, AND RESULTS

	Grade 1	Grade 2	Grade 3	Grade 4
No lymph nodes removed*	23 (60.52% of 38)	9 (23.68% of 38)	4 (10.52% of 38)	2 (5.26% of 38)
Information	23 (100% of 23)	8 (88.88% of 9)	4 (100% of 4)	2 (100% of 2)
Living	19 (82.69% of 23)	2 (25.00% of 8)	1 (25.00% of 4)	
Good result	18 (94.73% of 19)		1 (100% of 1)	
Poor result	1 (5.26% of 19)	2 (100% of 2)		
Dead	4 (17.40% of 23)	6 (75.00% of 8)	3 (75.00% of 4)	2 (100% of 2)
Good result	1 (33.33% of 3)			
Poor result	2 (66.66% of 3)	6 (100% of 6)	3 (100% of 3)	1 (100% of 1)
Total good result	19 (86.36% of 22)		1 (25.00% of 4)	
Total poor result	3 (13.63% of 22)	8 (100% of 8)	3 (75.00% of 4)	1 (100% of 1)

*A one-stage operation was performed such as the Quenu-Tuttle or Harrison-Cripps.

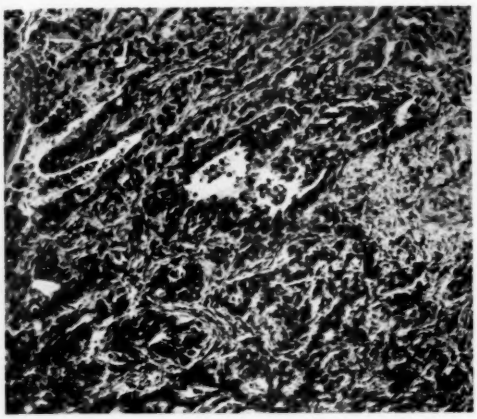

Fig. 5. Adenocarcinoma, graded 3, showing less cell differentiation than Figure 4 with irregular acinar formation.

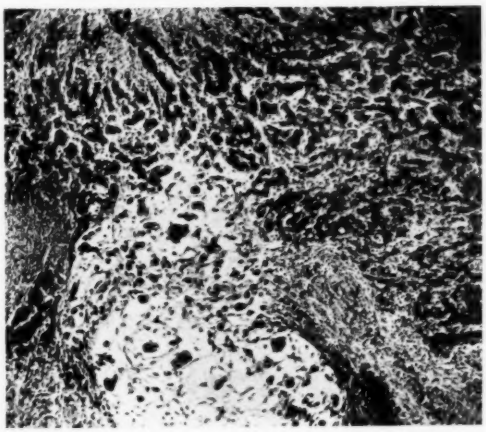

Fig. 6. Adenocarcinoma, graded 4, with mucoid formation. Note the undifferentiated state of the cells, for the most part, and the ill-defined acini.

Mitotic figures may or may not be numerous but are often irregular (multiple mitosis). When acini or gland formations are found in such carcinomata, the cells are not in good alignment and show very little tendency to individual cell differentiation.

In our series of carcinomata we have found a number that show mucoid or colloid secretion. This material may be associated with cells in all degrees of differention; however, on the whole, if it is found in large masses the cells associated with it are usually of a columnar type. One often sees acini so distended with this material that a number or all of the cancer cells in them have been destroyed by pressure. When the material is associated with undifferentiated cells it is usually less in amount and is often retained in the cell, giving it a signet-ring appearance.

GRADES OF MALIGNANCY

The malignancy of carcinoma of the rectum, like that of carcinomata in other situations, is subject to gradation on the fundamental principle of cell differentiation. In 1915, one of us (Broders) began grading malignant neoplasms on the fundamental principle of cell differentiation, and during the following 4 years, 1,628 squamous-cell epitheliomata were graded strictly from a microscopic viewpoint and absolutely independently of the clinical histories. In 1925 it was thought best to modify the original basis to some extent. The mitotic figures and the one-eyed cells were considered only as undifferentiated cells and it was only in the presence of numerous irregular mitotic figures that there was an inclination to raise the grade.

Recently we have studied 598 cases of carcinoma of the rectum operated on between 1916 and 1925 and graded the malignancy in accordance with Broders' method. From Table I it can be plainly seen that the percentage of cases in which metastasis is present rises in direct proportion to the grade of malignancy and that absence of metastasis increases in inverse proportion to it.

Table II shows the grade of malignancy and its relation to the ultimate result. The percentage of total good results decreases in inverse proportion to the grade of malignancy and the percentage of total bad results increases in direct proportion to it.

Table III shows the relationship of metastasis, grade of malignancy, and ultimate results. It is evident from the total percentages that the good results decrease in inverse proportion to the grade of malignancy and the bad results increase in direct proportion to it.

Table IV shows the relationship of absence of metastasis, grade of malignancy, and ultimate results. The percentage of total good

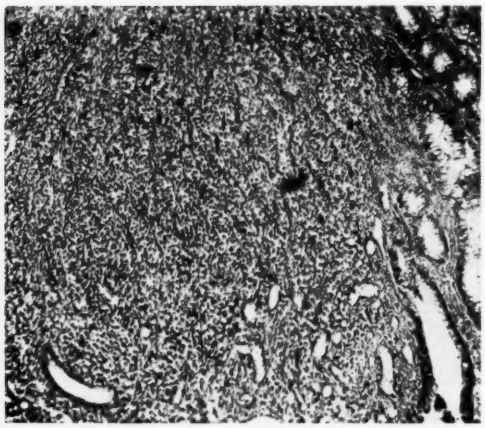

Fig. 7. Melano-epithelioma of anus, graded 4. Note the normal mucous glands to the right. Differentiation in the cells of this carcinoma is practically absent. Melanin was found only in spots.

results decreases in inverse proportion to the grade of malignancy, and the percentage of total bad results increases in direct proportion to it. While the grade of malignancy has its influence on the good and bad results in the absence of metastasis, this influence is not as marked as when metastasis is present. It can also be noted that in cases of carcinoma graded 3 or 4 without demonstrable metastasis the result is not much better than when metastasis accompanies a carcinoma graded 1.

In Table V the grade of malignancy and the results are compared in a series of cases in which the nature of the operation precluded the removal of lymph nodes.

Table VI shows the relationship of grade of malignancy, ultimate result, and duration of life since operation. It can be seen that the grade of malignancy plays practically no part in the average duration of life of those who are living, and it plays practically no part in the duration of life of those who died after a good result, but it plays a part in the average duration of life in those who died from the carcinoma, since the average duration decreases as the grade of malignancy increases (Figs. 1 to 7).

CONCLUSIONS

1. Extrinsic influences are, in the main, modifying in type, age being one which emphatically prejudices successful prognosis.

2. Duration of the growth is important but its exact determination is difficult, change in bowel habit and obstructive phenomena being the most dependable signs which call attention to the presence of a growth.

3. Fixation influences operability and, in consequence, operative mortality and successful outcome. Fixation in many instances is the result of inflammatory changes rather than direct extension of malignancy and, in consequence, radical maneuvers in selected cases give unexpectedly successful results, although this is the exception rather than the rule. Occasionally drainage operations permit a recession of inflammatory processes and sub-

TABLE VI.—GRADE OF MALIGNANCY, ULTIMATE RESULT, AND DURATION OF LIFE

	Grade 1	Grade 2	Grade 3	Grade 4
Total	105	299	141	53
Information	103	293	139	52
Living	58	112	35	8
Good result	55	101	33	7
Longest	9.50 years	11.00 years	10.50 years	10.33 years
Shortest	1.33 years	1.20 years	1.33 years	4.00 years
Average	5.06 years	4.79 years	4.57 years	6.73 years
Poor result	3	11	2	1
Longest	2.25 years	3.41 years	1.91 years	2.75 years
Shortest	1.37 years	1.16 years	1.41 years	2.75 years
Average	1.90 years	2.54 years	1.66 years	2.75 years
Dead	45	181	104	45
Good result	4	13		2
Longest	8.50 years	10.12 years		6.58 years
Shortest	1.83 years	1.17 years		4.00 years
Average	4.81 years	4.67 years		5.29 years
Poor result	25	142 (139 time stated)	87 (85 time stated)	35 (33 time stated)
Longest	7.75 years	7.66 years	6.00 years	7.75 years
Shortest	0.41 year	0.50 year	0.08 year	0.12 year
Average	2.42 years	2.21 years	1.76 years	1.45 years

sequent resection after immobility has been considered sufficient to rule out resection at the primary exploration.

4. Site of the growth influences outcome because of pathological type and early detection, epitheliomata of the anal canal being early recognizable and satisfactorily removed by local operation while the type of neoplasm found higher in the rectum is practically always adenocarcinomatous.

5. The grade of malignancy has a direct bearing on the percentage of metastasis and absence of metastasis since the percentage of cases showing metastasis increases in proportion to the grade and the percentage of cases without metastasis increases in inverse proportion to it.

6. The influence of the grade of malignancy on the ultimate result is indicated by the fact that the total of good results decreases in inverse proportion to the grade, while the total of poor results increases in proportion to it.

7. From a comparison of the influence of metastasis and that of the grade of malignancy, it is obvious that the grade of malignancy is the dominant factor since the total of good results decreases in inverse proportion to the grade and the total of poor results increases in proportion to the grade.

8. When the influence of the absence of metastasis and of the grade of malignancy on the ultimate result are considered together, the influence of the grade is still evident but not to such a marked degree as when it is considered with metastasis.

9. If the percentage of metastasis increases as the grade rises, and the influence of the grade of malignancy on the ultimate result has been established beyond doubt, it is reasonable to assume that the total of the good results in the presence of metastasis will not be as high as, and poor results higher than, when metastasis is absent; furthermore the total of good results when metastasis is absent should be higher, and the total of poor results lower, than when metastasis is present. Actually the total of the good results when metastasis was present was 20.68 per cent and the total poor results was 79.31 per cent. When metastasis was absent, the total good result was 57.87 per cent and the total of the poor result was 42.12 per cent.

10. It will also be noted that almost as good a result is obtained in the case of carcinoma of the rectum, graded 1, with metastasis as in the case of carcinoma, graded 3 and 4, without metastasis. Furthermore there has not been a good result in this series when malignancy was graded 4 and metastasis was present.

11. The influence of the grade of malignancy on the duration of life after operation in cases in which death occurred from the carcinoma is shown by the fact that the average duration decreased as the grade increased.

HYDATID DISEASE OF THE KIDNEY

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HYDATID disease is distributed throughout the world in those countries that have become famous for wool-growing; Australia, New Zealand, Argentine, Iceland, Southern Europe, and Northern Africa.

In Australia the name tænia echinococcus has become restricted to that for the parasite itself. When it attacks human beings it assumes the bladder-worm stage and the condition produced is always known as hydatid disease.

Sheep, dogs, and men are the three factors concerned in the development of the disease. It takes on an average of 15 to 20 years from the time of infestation before the patient seeks surgical relief, so slowly and insidiously does hydatid disease progress. If the encouragement of wool-growing in the United States of America and Canada continues, we feel sure that the next generation of surgeons in these two great countries will have more opportunities of studying the manifestations of hydatid disease than their predecessors had.

Public health measures in Iceland and Australia have brought about a definite reduction in the disease as manifested in man. Sheep farmers know the danger of feeding their dogs on the uncooked livers of infested sheep. This one step arrests the disease at its source.

Of 1,460 cases of hydatid disease admitted into the Royal Prince Alfred Hospital during the past 42 years, in 28, or 1.9 per cent, the disease affected the kidney. It is not a common disease. During the past 15 years, 16 cases of renal hydatid have come under our observation. A summary of the histories is appended. Of these: 11 were males, 5 were females; 8 were in the right kidney, and 8 in left. The average age when the patients were seen was 40 years. The youngest patient was 9 years old, the oldest, 67.

The hydatid embryo may reach the kidney at the primary infestation of the host even if the infestation consists of only a single embryo. If the infestation consists of many embryos, then the kidney will share misfortune with other organs.

A secondary infestation of the kidney may occur from the rupture of a hydatid cyst into some part of the blood stream. If the patient survives this disaster, the kidney along with other organs may be the seat of many hydatid cysts. Clinically there may be so many tumors present that the diagnosis of secondary malignant disease is made. This type of multiple infestation of the kidney is usually discovered postmortem and has never in our surgical service come within the scope of operative surgery.

In this series of cases we include only those hydatids that arise within the kidney substance. Some authors (10) include infestation by "implantation on the juxta renal peritoneum." In the surgical service of the Royal Prince Alfred Hospital, Sydney, we have not seen a hydatid cyst which has invaded the kidney in this way. Many have been found in contact with the kidney but never truly invading it. Expansion of a hydatid occurs along the line of least resistance, which is, under these circumstances, toward the peritoneal cavity and away from the kidney.

If a hydatid were anchored by firm peritoneal adhesions close to the kidney, it would be theoretically possible for it to invade the kidney. We have yet to see this happen.

Hydatids within the peritoneal cavity should be classified as abdominal or peritoneal. They arise from traumatic or spontaneous rupture of a hydatid of the liver or spleen into the peritoneal cavity. The kidney peritoneal pouches as well as other pouches are involved in a general infestation of the peritoneal cavity. This type of infestation also follows the

Fig. 1. Hydatid of the lower pole of the left kidney. Anterior aspect.

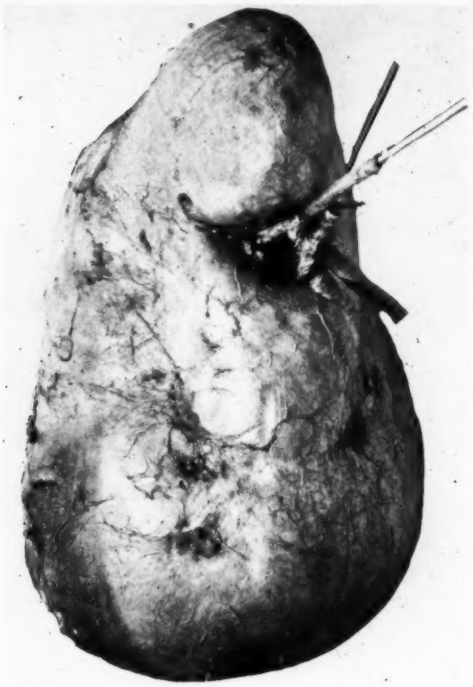

Fig. 2. Same kidney as that shown in Figure 1 from medial aspect.

Fig. 3. Cystic malignant growth of right kidney closely resembling hydatid of the kidney.

Fig. 4. Small hydatid of the left kidney containing two daughter cysts.

Fig. 5. Calcified hydatid of the right kidney with calcified hydatid of the liver above.

Fig. 6. Calcified hydatid of the right kidney containing calcified daughter cysts.

practice of tapping a hydatid cyst of the liver by means of an exploratory syringe. Some of the contents leak out of the needle puncture into the serous cavity. The manifestation of secondary infestation brought about in this way may be postponed for many years. We have seen it happen 20 years after the original tapping or rupture.

It was for this reason that tapping, exploratory or as a means of treatment, has been abandoned.

We cannot classify Allaben's case quoted by Kretschmer (5) as one of hydatid of the kidney.

Fig. 7. Hydatid of the lower pole of left kidney; longitudinal section. Sectioned after hardening.

The hydatid embryo is blood-borne in the same way as a bacterial infarct, and like it usually comes to rest in the outer part of the cortex of the kidney. Theoretically there is no part of the secreting or collecting kidney tissue that is exempt from the risk of infestation.

The course of the disease is governed by the site at which the embryo comes to rest. Those in the upper pole are more fraught with danger than are those in the lower because of the proximity of the liver and spleen. As the disease progresses, attachment to, and invasion of, these organs may take place. We have had an example of invasion of the liver and eventually of the lung on the right side, also invasion of the spleen in a left renal hydatid. Whether a hydatid of the liver or spleen immediately above the kidney can gain attachment to that organ and then in-

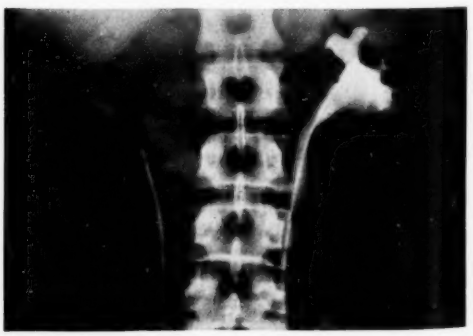

Fig. 8. Pyelogram of same patient as shown in Figure 7. Note the filling defect of lower major calyx.

vade it, is a question we cannot yet answer from our observations; but we believe it possible and even probable. In advanced cases it might be difficult to determine whether the hydatid started in the liver or kidney.

In the lower pole, when the spherical hydatid reaches the capsule of the kidney, expansion takes place along the line of least resistance and that is toward the lower half of the abdominal cavity. In this region, enormous expansion may take place without interference with important organs. Local peritonitis sometimes occurs as the growth expands, and in one case acute intestinal obstruction developed from peritoneal adhesions.

In the middle region of the kidney the parasite expands until eventually the whole kidney substance is destroyed.

Contrary to the experience of others (10), we have found that displacement of the kidney does not occur in this disease. It is the hydatid that becomes displaced and not the kidney. This is borne out by a pyelogram of an upper pole hydatid published by Kretschmer (5), also by a pyelogram of a lower pole hydatid in our series published with this communication.

Hydatid may occur in a prolapsed kidney and give the impression of displacement; also there may be an accompanying hydatid of the liver which is pushing the kidney from above. Evidence of this is also shown by the accompanying pyelogram.

INFECTION

It has been accepted up to the present time that suppuration may take place in a hydatid that has not ruptured into a secretory channel of the body of the host. From our observations we doubt this statement. We have never seen suppuration in a hydatid of the kidney that has not ruptured into the renal pelvis or a calyx. A suppurating hydatid of the liver is almost invariably bile stained, or bile appears within a day or two in the drainage tube after operation. A hydatid of the lung suppurates only when it communicates with a bronchus.

The infection and suppuration has been accepted as the cause of the hydatid rupture. It is more likely in our opinion that the reverse of this is true; that the rupture is in reality the cause of the infection.

In offering this suggestion we are influenced by the fact that there is no direct blood supply to carry bacteria to a hydatid cyst; that it is fed by osmosis only, through a dense avascular adventitious cyst wall together with a laminated chitinous ectocyst of considerable thickness. These structures, unless actually broken by trauma, would appear to be an efficient bacterial filter. Once a hydatid has broken into the upper urinary tract or into a bile duct, or into a bronchus it is directly open to the attack of organisms that are known to be sometimes, if not always, present in these channels.

Quite apart from the question of infection, the parasite, when it makes its way through a mucous lined path to the outside world, is only fulfilling its biological object in life—the perpetuation of its species.

It has been our experience in infected renal hydatid that the degree of infection is always mild, sometimes the pus proves to be sterile on culture in all ordinary media. It is only after operation and drainage that more virulent infections manifest themselves. Postoperative infection is more common in the liver than in the kidney. This postoperative infection sometimes has killed the patient but it has had the virtue of always killing the parasite if the patient survived and the drainage tube were left in long enough. The smell of a suppurating hydatid during the first few weeks after operation is something to be remembered. You can tell at once on entering a ward if there is a case present. The opportunities of experiencing this peculiar but not altogether offensive odor are rare, since the adoption of methods which avoid large drainage tubes either by the use of rubber dam or by complete closure of the wound without drainage after emptying and sterilizing the cyst cavity.

CLASSIFICATION

Hydatids of the kidney have been so far included under one head; but there is a fundamental pathological fact which divides them into two natural groups, not only from the point of view of symptomatology but from the point of treatment as well.

This fact is whether the hydatid communicates with the renal pelvis or calyx, or does not do so. Those that communicate with the urinary channels we have classified as open, those that do not, as closed. The analogy of joint tuberculosis suggested the classification. Subdivisions of these two types may be made as follows:

Open and closed hydatid
- Active living
- Calcified living and dead
- Infected living and dead

CLOSED-HYDATID SYMPTOMS

Until a hydatid has ruptured into a calyx, the symptoms are those of renal tumor only. The patient may feel a movable lump in the abdomen without any pain beyond perhaps a sense of dragging or discomfort aggravated by exercise. As the cyst enlarges, symptoms of diaphragmatic pleurisy may develop if the tumor is in the upper pole or local peritonitis if it is in the middle region or the lower pole.

In Australia, if we meet with an approximately spherical tumor in any part of the body, the possibility of hydatid is always considered, particularly if the patient has lived in a sheep district. The size of the tumor may be considerable and yet the general health of the patient remain quite up to normal standard. This combination of tumor with unaffected general health is strongly suggestive of hydatid. Hæmaturia is said not to occur in closed hydatids of the kidney, but in 3 of 6 cases in our series it was present; in 2 it was macroscopic and in 1 microscopic; in 1 there was associated nephritis indicated by numerous casts; the second closed hydatid was dead and calcified; the third was the classical closed type about 4 inches in diameter.

In hydatid of the lung, hæmoptysis occurs in some cases for some time before rupture into a bronchus takes place. There is no reason why the same relative phenomenon may not take place in renal hydatid. The hydatid cyst may be long in contact with the mucous membrane of the pelvis or calyx before actual rupture of the cyst wall occurs. While in such contact, some irritation, œdema, and congestion of the mucous membrane must be present. Slight trauma under these circumstances could produce hæmaturia.

OPEN HYDATIDS OF THE KIDNEY

When once the hydatid has burst into the urinary tract, the patient is dramatically reminded at intervals that something is really wrong and he seeks surgical advice. Hæmaturia, colic, and the passage of daughter cysts either whole or collapsed are the three cardinal features of the history. The patient usually describes the hydatid débris as pieces of jelly or grape skins. The colic is exactly similar to that caused by renal or ureteral stone and is as variable. The hæmaturia may vary from the most profuse type down to microscopic red blood cells. It is possible for a renal hydatid to be cured by nature's method much in the same way as a hydatid of the lung. It may be voided through the natural channels. In one of our series (Case 16) this almost happened. The removed kidney on section showed only two remaining small daughter cysts. A fortnight before, the patient had passed several ounces of hydatid débris and blood clot. The two small daughter cysts left behind would have been quite enough to start the hydatid all over again.

The interval between attacks varies from a few days to a few months according to the relief of tension within the cyst. If a small amount of débris passes, then an attack may very soon come on; if a large amount passes many months or even 1 or 2 years may pass before the tension within the cyst rises sufficiently to cause bursting again.

During an attack, hydatid fluid and daughter cysts escape until one of the daughter cysts falls over the opening into the calyx like a ball valve.

We have had the unique opportunity of seeing this actually happen during the cystoscopic examination of a retrovesical hydatid which communicated with the bladder through an opening in the posterior wall big enough to admit the cystoscope. We looked into the living hydatid and saw the daughter cysts floating about like pearly grey spheres. When the cystoscope was withdrawn, a few daughter cysts would escape, then one large enough and tough enough would drop over the opening into the bladder and seal it. What happens in the bladder must happen in the kidney.

When once the hydatid has burst into the urinary tract further increase in size of the parent cyst ceases. Any increase in tension due to the natural growth of the cyst is relieved by the safety valve action of the opening into the calyx. In one of our series, no alteration in size of the tumor had taken place in 10 years, although the patient stated that before one of his attacks of hæmaturia and renal colic he thought he could feel "the lump" more easily.

In hydatids of the upper pole when once the liver or spleen has been invaded, the safety valve action does not control further invasion of these two organs.

Calcified hydatids of the closed variety as a rule produce no symptoms and they are discovered only in a routine urological examination for some intercurrent disease. Under trauma they may lead to severe hæmaturia but seldom if ever sufficient to justify surgical interference. A fully calcified hydatid is a dead hydatid and unless causing symptoms should be left alone.

A calcified hydatid of the open type may cause symptoms of renal colic from the passage of calcified débris down the ureter. Surgery is then indicated. Case 15 was of this type.

Cystoscopic examination yields the evidence of a turbid efflux from the ureter during an attack of hæmaturia. The mucous membrane of the bladder is seldom involved even in infected open hydatids of the kidney. In one of the series (Case 6) an acute cystitis was found; but we were not convinced that there was any relationship between the calcified hydatid of the kidney and the cystitis.

In open renal hydatids routine microscopical examination of the bladder and kidney urines may reveal besides red blood cells, pus cells and hydatid hooklets. What is just as characteristic and less difficult to find, is fragments of laminated, chitinous hydatid membrane. Nothing else resembles it.

Functional test by phenolsulphonephthalein. Unless gross destruction of the kidney has been brought about, we have not found any difference in function between the two kidneys. In one case where the right kidney was destroyed, there was a complete absence of function on that side.

Pyelography is of great value when a positive deformity is shown, but the absence of deformity does not exclude the presence of hydatid. Kretschmer (5) published a pyelogram of an upper pole hydatid which showed deformity of the upper calyces. We show a pyelogram of a lower pole hydatid which illustrates a filling defect of one of the lower calyces. In the future, we expect to be able to demonstrate some deformity in the pyelogram of all open hydatids of the kidney.

In a closed hydatid of the lower pole of the kidney, no deformity of any calyx could be demonstrated. This is true of solitary cysts of the kidney which, like closed hydatids, when once they have reached the capsule, expand like a hernia in a radial direction away from the center of the kidney. No pressure is exerted on the calyces or pelvis. If the closed hydatid is situated in the center of the kidney, a deformity would be expected. We have yet to demonstrate this.

We had the opportunity of taking a pyelogram of a case in which the whole kidney had been destroyed by the hydatid. Nothing but the blind upper end of the ureter could be demonstrated opposite the second lumbar transverse process.

On pyelographic evidence there should be little difficulty in differentiating a hydatid from a solid tumor; the latter causes more spider-like deformity than a hydatid of the same size. Pyelography cannot differentiate between a solitary cyst of the kidney and a closed hydatid.

LABORATORY TESTS

Blood count. Much work has been done in Australia during the past 20 years to develop tests that could be relied on in the diagnosis of hydatid disease.

In common with other parasitic worms that infest the human race, the echinococcus alters the relative percentage of the white cells of the blood. Welsh and Barling (8) (*Australian Medical Gazette*, August, 1906, 383) found that the eosinophile count was increased in 50 per cent of the cases observed. This is a test that we use today, and if positive it is of considerable value. One of our cases showed an increase from the normal 2 per cent to 20 per cent.

Precipitin reaction. Welsh, Chapman, and Storey (9) (*Australian Medical Gazette*, December, 1908, 653; and *Lancet*, April, 1909, 1103) showed that the precipitin was derived not from the antigen but wholly or almost wholly from the antiserum.

Dew and Williams found that the precipitin test and the complement deviation test run a parallel course but the former is not so delicate, nor is it quantitative in the same way. It proved positive in 70 per cent of the patients examined (3).

Complement fixation test of Ghedini. Fairley (4) has shown that the complement fixation test of Ghedini is positive in 84⅓ per cent (84.3 per cent) when tried in a series of 83 cases.

Dew and Williams (3) confirmed these findings and showed that if this test were combined with the *intradermal test of Casoni* a positive finding should be obtained in 90 per cent of the cases of hydatid disease.

Intradermal test of Casoni. Dew, Kellaway, and Williams (2) using the intradermal test of Casoni alone found it better than the complement fixation test. It gave positive findings in 92 per cent of the uncomplicated cases.

In clinical work we have found, as have others, that the reliability of these tests depends upon the freshness of the antigen. If fresh hydatid fluid from the cysts in the liver of a sheep is used, reliance can be put on the result. The addition of phenol to make a solution of 0.5 per cent enables the antigen to be kept for some months if placed in an ice chest. If the antigen is old, pseudo-positive results may appear in patients who do not suffer from hydatid disease. We have found that the error may be 10 per cent. In other words, if 20 patients who are in a general surgical ward are tested with antigen that is 2 months old, 2 may give a positive result. When these 2 are tested with fresh antigen they give a negative result. This experiment requires repetition but it is sufficient to demonstrate the weakness of these tests. In spite of this we are coming to rely more and more upon the tests of Ghedini and Casoni as an aid in the diagnosis of hydatids. When a reliable antigen is obtained that will keep for at least 6 months it will be of service in all countries.

DIAGNOSIS

In a review of our series of cases, it is interesting to note the improvement in the percentage of pre-operative diagnosis since full routine urological investigations have been made. Previous to this period there were 8 cases, 3 of which were correctly diagnosed. Since full investigations have been made the rule, 7 of 8 cases were correctly diagnosed before operation. The eighth case was strongly suspected as being of hydatid nature but the complement deviation test was inconclusive and the Wassermann test was strongly positive. For these reasons a malignant or syphilitic tumor of the kidney was given preference.

It is only fair to mention that in the first 8 cases, 6 were closed hydatids and 2 were open, while in the last 8 only 3 were closed, and 5 were open. As has been pointed out, the pre-operative diagnosis of a closed hydatid is much more difficult than that of an open one. All open hydatids of the kidney should be correctly diagnosed. In 1 of the first 8 cases, the hydatid was discovered postmortem, the patient having died of acute bronchopneumonia and cholelithiasis.

In palpating kidney swellings, we have adopted for more than 10 years a method of examination in which we apply with the fingers of one hand strong pressure from behind in the costo-vertebral angle with the object of lifting the kidney out of its paravertebral groove, while light pressure is applied in front with the other hand. This method preserves all the delicacy of light tactile sensation and reveals enlargements of the kidney that otherwise would be missed. Probably many others use the same means. Spurr describes a method of "lateral percussion and palpation" to determine the presence of kidney swellings. This method embodies the same principle of lifting the kidney out of its groove (6).

In our experience a full clinical history and urological investigation has so far been of greater service than laboratory tests; but these tests are becoming increasingly important in the chain of evidence. In closed hydatids they are of more use than in the open type. In the open type, a positive diagnosis should

be arrived at without their aid. A microscopic examination during an attack of renal colic and hæmaturia, and even between attacks, should reveal the presence of hooklets, or what is more common but equally characteristic, a fragment of laminated chitinous cyst wall.

If when the tumor is palpated the characteristic hydatid thrill can be elicited it is a pathognomonic sign. Unfortunately it is rare and difficult to find in any part of the body and especially so in the kidney. In 1 of our 16 cases, a hydatid of the lower pole in which the tumor came well down toward the iliac fossa, we could elicit the thrill. We were able to secure the thrill by pressing on the medial side of the tumor with one hand and percussing on the flank with the middle finger of the other hand. The fluid and semi-solid contents of the cyst gave the sensation of quivering under the percussion finger. If a cylindrical tin container with a thin top and bottom is filled with boiled starch, of the consistence of *blanc mange*, the hydatid thrill can be demonstrated by tapping the lid. Another material that can be used is *linimentum terebinth* (*British Pharmacopœia*).

TREATMENT

The recognition of the fact that there are two types of hydatid of the kidney—the open and the closed—and that each type requires different treatment, simplifies the surgery of this disease. With the opportunities at our disposal, we are now able to give our views upon the indications for and choice of operation with some measure of clearness.

We are satisfied that all living hydatids should be treated surgically until such time as a drug is discovered that will kill the parasite without killing the host. Tartar emetic has transformed bilharziasis from the domain of surgery to that of medicine. Let us hope that some such drug may be discovered for hydatid disease.

If untreated, the disease takes a long time to kill a patient but kill him it almost certainly will. We have evidence that it can cause sudden death from embolism or anaphylaxis; that it can produce intestinal obstruction; that it can extend to other organs; and that during its progress it can inflict much needless suffering on the patient.

In surgical literature, nephrectomy is recommended as the operation in all cases of hydatid of the kidney. We would agree with this recommendation if it were restricted to all cases of open hydatids of the kidney. If the kidney pelvis is in communication with the infected or uninfected cyst, nephrectomy is indicated if it can be performed. It is surgically unsound to leave a cavity in communication with the urinary tract which, if not infected previous to operation, is very likely to be afterward.

In 2 open hydatids in our series, nephrectomy had to be abandoned on account of severe hæmorrhage when the adhesions to the liver were separated in 1 case, and to the spleen in the other case. Marsupialization with drainage was carried out as the next best step. One case (Case 10), lived for 10 years and died at the age of 69 from liver, pleural, and pulmonary extensions of the original kidney hydatid. The other (Case 9) died suddenly 2 years afterward from hydatid embolism or anaphylaxis. The urine of both these patients was infected up to the time of death.

Closed hydatid of the kidney differs in no essential from a hydatid of the liver. Marsupialization or Lindeman's operation in some form has proved for nearly 50 years a safe, sound procedure for closed liver hydatids. In our work it has proved applicable to kidney hydatids. This operation was carried out in 5 cases of closed hydatids in our series with uniformly good results, both immediate and remote. A closed hydatid of the upper or lower polar region of the kidney never destroys the whole of the organ. Sufficient cortical tissue remains to justify a conservative operation.

Today, improved serological tests render the task of diagnosis of closed hydatids of the kidney an easier one; but if a pre-operative diagnosis cannot be arrived at, it is not advisable to do anything but a nephrectomy because of the risk of mistaking a malignant cyst of the kidney for a hydatid. In one case, a sheep farmer had a spherical renal tumor, 10 centimeters in diameter. A Ghedini and Casoni test gave a negative result for hydatid disease,

yet we felt that he might still have a hydatid. When the kidney was exposed, a cystic tumor was found in the middle region of the kidney that closely resembled in appearance a hydatid cyst, but it was not so tough and fibrous on palpation nor so yellowish in appearance; it was more reddish in color and more cellular on palpation. As the type of tumor could not be definitely determined a nephrectomy was performed. It proved on pathological examination to be a malignant cystadenoma of the kidney. (See Fig. 3.)

Calcified hydatids of the kidney require no operation if they are of the closed type, unless they give rise to repeated hæmaturia. We have so far not operated on any. In the open type, infection of the cavity accompanied by repeated attacks of renal colic from the passage of débris calls for a nephrectomy.

Partial or subtotal nephrectomy is now established as a sound surgical procedure in certain pyogenic infections of the kidney localized to the polar regions. There is no reason why it should not be applied in selected cases of hydatid of the kidney if the function of the other kidney is below normal standard; or if the operation can be carried out without undue risk to the patient. The renal tissue not invaded by the hydatid is healthy tissue. Both the open and closed type of hydatid should be amenable to the treatment suggested provided there is enough normal kidney tissue left to justify the added risk of this operation.

No opportunity has as yet presented itself to us to use this method of treatment; but we hope to do so in the near future. We offer the suggestion to our colleagues over-seas, in case they may be more fortunate in getting an earlier opportunity to put this conservative method of treatment to the test.

OPERATION

Of the 16 cases in our series, 13 were submitted to operation and 3 were not (Table I). There were no deaths due to the operation while the patients were in the hospital or after they had left the hospital.

Tapping as a therapeutic measure is obsolete for reasons already given. Lindeman (7) in 1879 described his operation for hydatid

TABLE I.—SUMMARY OF SIXTEEN CASES

	Number of cases
No operation—Cases 4, 6, and 14 (In Case 4 cyst was discovered postmortem)	3
Nephrectomy—Cases 3, 12, 13, 15, 16	5
Marsupialization or nephrostomy—Cases 1, 2, 5, 7, 8, 9, 10, and 11	8
Total	16

cyst. He exposed the cyst, emptied its contents by incision, and then stitched the adventitious cyst to the abdominal wall. His operation we call marsupialization from the analogy to our kangaroo's pouch. This is the operation that, with certain precautions, we perform today in all cases of hydatid of the kidney which do not communicate with the renal pelvis; the type that we classify as closed, provided a pre-operative diagnosis is made.

The precautions that we take are to prevent the soiling of the perirenal areolar tissue with cyst contents. The necessity for these precautions is emphasized by the work of Dew, which demonstrates the capacity of even the minute scolices to produce secondary infestation.

Influenced by Edwin Beer's technique for the prevention of secondary implantation of papillomata of the urinary bladder, we are using alcohol to lessen the danger of secondary hydatid infestation. Any surgeon familiar with Beer's technique in suprapubic cystotomy for bladder papillomata could operate with confidence in hydatid disease of the kidney provided he followed the same principles.

We expose the cyst at its most superficial part—usually this is in the loin. If it is in front near the iliac crest we make a muscle-splitting incision as for an appendix but avoid going through the peritoneal cavity. When the cyst is exposed, it is seized with Allis' forceps, and a trochar attached to a suction apparatus is plunged toward the center. As the contents are evacuated, the cyst wall is drawn well up into the wound and packed off with dark colored gauze, preferably black, to facilitate the recognition of the contents that may escape. The fluid drawn off is measured and an amount of alcohol slightly less than this is injected into the cyst, where it is left to act as a devitalizer for 3 to 4 minutes. The alcohol is then withdrawn, and the cyst contents

evacuated through an incision made at the site of the trochar puncture. An instrument shaped like a long handled teaspoon or tablespoon is useful in removing the numerous daughter cysts. It sometimes takes half an hour to three-quarters of an hour or longer to clean out a large cyst thoroughly. A wide bore suction apparatus is also of help in cleaning the recesses. When this cleansing is accomplished we again treat the collapsed cyst by swabbing it out with alcohol. Before the cyst is incised, or after it is emptied, the adventitious cyst wall is stitched to the deep aspect of the abdominal muscles with chromicized catgut that will last for 14 days at least. The incision in the cyst is left open. The abdominal wound is then closed in layers with a small rubber dam drainage down to, but not into, the cyst. This drain is removed in 3 or 4 days if all goes well. Sometimes the cyst drains freely for a longer period; when this occurs we allow the rubber dam to remain longer. We have given up the use of large calibered rubber tube drains as they lead to postoperative infection. If the cyst is large and communicates with the liver or spleen, we make an exception and use large tubes. Under such circumstances, daughter cysts may be discharged through the tube for many weeks, as it is impossible to evacuate the irregular cavity thoroughly if the cyst proves to be of the branching loculated type.

The safest method of all to prevent the escape of cyst contents into the perirenal tissue is a two-stage operation. At the first step the cyst is exposed by the usual method and stitched to the abdominal wall. The wound through the abdominal muscles is left open and packed with gauze. Ten to 14 days later when adhesions have shut off the surrounding areas, the cyst is evacuated as described.

The two-stage operation has been successfully used in hydatid of the brain and certain deeply situated abdominal hydatids. Up to the present, we have not seen the occasion to use it in hydatid of the kidney.

Formalin in 10 per cent solution is used by some Australian surgeons in the same way as we use alcohol to devitalize the parasite. It is claimed to be quite satisfactory.

The Bond-Delbet-Posadas operation in which the cyst is opened, evacuated, and allowed to drop back without being stitched to the abdominal wall, we have not done. While many brilliant results by primary healing have followed this method there have been in Australia sufficient postoperative deaths from leakage and infection to restrain us from attempting it. With all the precautions that are taken, it is difficult to be sure that every scolex has been destroyed by the alcohol or formalin. If the cyst is dropped back without being secured to the abdominal wall, any living scolex will lead to a secondary implantation in the deep perirenal tissues; if it is stitched to the abdominal wall, implantation can take place only in the superficial scar tissue. This complication arose in one of our series (Case 10). We had no difficulty in excising completely the whole cyst with some surrounding scar tissue.

The operation of nephrectomy through the usual oblique lumbar incision presents no more difficulties in hydatid disease than it does in any other disease of the kidney.

The opportunities of studying the clinical aspects of hydatid disease that have fallen to the lot of the surgical staff of the Royal Prince Alfred Hospital, particularly during the past 30 years, are unlikely to occur again in the same space of time.

It is with the object of placing one phase of this disease before our colleagues in other countries that this communication has been given. At the same time we wish it clearly understood that we are giving our own personal views and do not imply that they necessarily represent the views of other members of the surgical staff.

CASE 1. C. S., female, age 21 years. Family history good; no previous illnesses. For the past 2 years patient has had dragging, bearing-down pain on the right side of the abdomen, attributed to heavy work. The pain has been worse during the last 10 months; has been constant and worse after exertion. It is confined to the right side of the abdomen and to the right loin. Attacks of vomiting have occurred 5 and 3 weeks ago. During these attacks there has been marked increase of pain in the right side of abdomen and right loin. During the last few months there has been increased frequency of micturition accompanied by occasional scalding; three to four times during the day, twice

at night. There has been hæmaturia on 4 occasions during these last few months, bright red and intimately mixed with the urine. Examination of the urine showed reaction, acid; specific gravity, 1025; faint cloud of albumin; a few pus cells. A large, rounded tumor extended from the right loin to almost the midline in front; it was dull on percussion and moved on respiration. Operation consisted of a lumbar nephrostomy through which the contents of the cyst, consisting of innumerable daughter cysts and some pus cells, were evacuated. The edge of the adventitious cyst was stitched to the abdominal incision and a tube drain inserted. Patient was discharged from hospital 7½ weeks after operation with a sinus in the loin. General condition, excellent.

Case 2. R. C., male, age 43 years. Family history good; no previous illness. Three years ago he developed a left inguinal hernia which was not treated. Ten days ago he consulted a doctor, for pain in the region of the hernia. The hernia was reduced by taxis with some difficulty. The following day, swelling of the abdomen occurred accompanied by dull pain in the hypogastrium. Patient vomited 5 or 6 times a day for 8 days. Further abdominal swelling occurred during the last few days accompanied by much pain. The bowels were not open for 2 weeks. On admission to hospital the abdomen was very distended and tense. There was dullness extending upward toward the left hypochondrium and to the left loin. No result was had from a large enema. The urine was dark and scanty, with no albumin, no pus. Blood examination showed 2.5 per cent eosinophilia.

The hernial sac was exposed and found empty. The abdomen was opened through a paramedial incision in the left rectus. There was a large cystic mass filling the left side of the abdomen. The distended intestines were packed off, 5 pints of fluid withdrawn, and the cyst marsupialized. Examination of the fluid showed numerous hydatid hooklets, and urine was definitely demonstrated. Three weeks afterward, on account of insufficient drainage and a rising temperature, a left lumbar nephrostomy was performed. The cyst extended up under the diaphragm beyond the limits of the exploring hand. A drainage tube was inserted. Hydatid cyst wall and débris appeared in the drainage tube from the front opening. Two months after the first operation, the patient was discharged from the hospital. Both wounds had healed.

Case 3. C. K., sheep raiser, age 26 years. He had no previous illnesses. Three years ago he had a sudden sharp pain in the left loin radiating to the front of the abdomen toward the left groin. Vomiting occurred during the attack. Twenty-four hours later he passed in the urine a substance resembling grape skins. The urine was blood-stained. Since that time he has had 12 similar attacks occurring lately at more frequent intervals, and in some of these later attacks the pain has extended into the testicle. Examination shows a healthy muscular man. No definite tumor of the left kidney could be demonstrated. Pathological examination of the urine showed it to contain pus and blood. No hooklets seen. Blood examination showed the precipitin test for hydatid faintly positive. A left lumbar nephrectomy was performed. The lower pole of the kidney was occupied by a hydatid cyst, about 3 inches in diameter, filled with daughter cysts. Patient was discharged from the hospital 5 weeks after the operation. The wound was healed.

Case 4. M. J. P., female, age 33 years. Lived all her life in the country. Two weeks ago patient had a rigor followed by vomiting, diarrhœa, and jaundice. These symptoms have persisted ever since. For the last 12 months she has noticed a hard swelling in the left hypochondrium, with a dragging, bearing-down pain which gets worse on exercise. Since the onset of illness, there has been an increase of frequency of micturition accompanied by scalding. Urine has been dark in color. On examination we found patient jaundiced, with a hard rounded tumor situated in the left hypochondrium, movable on bimanual examination. Cystoscopy showed the efflux from the right ureter clear, that from the left turbid and blood-stained. There were pus and casts in both specimens, more marked on the left side. Blood examination showed 1 per cent eosinophilia. No operation was performed. Patient died 2 weeks after admission. Postmortem examination showed bronchopneumonia, cholelithiasis, and in both kidneys an acute nephritis. The lower pole of the left kidney was occupied by a spherical hydatid cyst containing numerous daughter cysts; but no communication was found with the urinary pelvis.

Case 5. V. M. O., female, age 19 years. Patient has always lived in the city. When she was 7 years of age, she had an operation for tumor of the liver, said to be hydatid. One year before admission she had acute right renal colic, and 1 month later she noticed a movable lump in the right hypochondrium. Nothing was done on account of the fact that she was 4 months pregnant. Since the birth of the child, the pain has become more severe and of a dull, dragging character, and the lump has increased in size. Examination showed there a large rounded tumor in the right hypochondrium, which was well felt bimanually and moved on respiration. The urine contained no albumin, sugar, or pus. Blood examination: 7 per cent eosinophilia. Through a right lumbar nephrostomy, a hydatid cyst with numerous daughter cysts was removed. The edge of the adventitious cyst was sewed to the abdominal wall. Convalescence was slow. The patient was discharged 8 weeks afterward with sinus still draining.

Case 6. W. H. B., male, age 67 years. Patient had an attack of hæmaturia 6 weeks ago, of sudden onset, accompanied by scalding and pain along the penis. This continued more or less until 10 days ago, when the symptoms almost completely subsided. X-ray examination showed a typical calcified hydatid in the right kidney. Cystoscopic examination showed a marked cystitis still present.

Examination of the urine showed pus cells, red blood cells, and motile organisms. The attack of cystitis completely subsided after 2 weeks' rest. As this attack of cystitis had no apparent relation to the calcified hydatid in the right kidney, no operation was advised.

CASE 7. G. C., male, age 58 years. Patient has lived at times in the sheep country since childhood. He is said to have had hydatid disease of the liver 28 years ago and 9 years ago. Three days ago he had a sudden acute pain in the left iliac region which was colicky in character. Urine at this time was as dark as treacle; stools were light in color. He vomited a month ago. He had some slight pain on micturition with increased frequency. Examination showed patient very jaundiced, with tenderness in the right hypochondrium, and the liver 4 inches below the costal margin. On the left side of the abdomen there was a tumor about 3 inches in diameter, movable on respiration, with its lower margin at the level of the iliac crest. A muscle-splitting incision was made at the level of the iliac crest and a retroperitoneal tumor was found arising from the lower pole of the kidney. This was opened and hydatid and daughter cysts were removed. The adventitious cyst was sewed to the abdominal wall and a drainage tube inserted. Patient was then turned on his left side and a trans-thoracic hepatotomy performed in the midaxillary line at the level of the tenth rib. The hydatid cyst was marsupialized after removal of its contents. Convalescence was slow. Patient was discharged 9 weeks afterward. Kidney wound had closed, but the hepatic wound was still discharging.

CASE 8. W. McD., male, age 9 years. Patient had had no previous illnesses. For the past 6 months the mother has noticed that there has been a swelling in the right side of the abdomen, which has increased in size from the time it was first noticed. The child has never complained of any pain and has been perfectly well in health. The urine has never shown any alteration from the normal. Examination showed a rounded swelling, 3 inches in diameter, in the right hypochondrium, tense, dull on percussion, which moved on respiration. A muscle-splitting incision was made over the most prominent part of the swelling, the contents of the cyst were aspirated, then it was opened and the daughter cysts and the endocyst removed. The margin of the adventitious cyst was then stitched to the peritoneum and the abdominal wall, and a rubber tube drain inserted. Five weeks afterward, patient was discharged from the hospital with a small sinus still discharging.

CASE 9. S. A. W., male, age 38 years. Patient lived in sheep country in his childhood and in the city during adult life. He has had no previous illnesses. Nine months ago he had a sudden severe colic-like pain in the left lumbar region. He was ill for 3 weeks. During this time he vomited once or twice a day. The urine was blood stained at intervals during this initial attack. He was well for 3 months and a similar attack of left-sided pain occurred, but there was no vomiting. Patient has had a constant dull, dragging pain ever since in the left loin. Five weeks ago there was a slight recurrence of the hæmaturia, no increase of frequency. At intervals during the last 5 weeks he has noticed that the urine has contained a substance "like jelly fish." The lower pole of the left kidney is palpable but not definitely enlarged.

Macroscopical urine examination showed collapsed daughter cysts present; microscopic examination showed laminated membrane, hooklets, pus, and blood.

The patient left the hospital at his own request, and returned a year later. He remained well until 4 months ago, when he noticed discomfort after eating accompanied by flatulence and pain in the left hypochondrium and left loin; no vomiting. During the last 8 weeks he has passed "grape skins" in the urine. Examination showed that the lower pole of the left kidney is still palpable but not more clearly than it was 12 months ago. Urine contained pus cells, red blood cells, and hooklets. Blood examination showed 6 per cent eosinophilia. Urine from right kidney decreased with cystoscope, contained no abnormal elements. No urine could be obtained from the left kidney, although there was a turbid efflux from this ureter before the passage of the catheter. The left kidney was exposed, and a hydatid cyst was found involving the upper pole of the kidney, extending nearly to the vertebral column, and upward to the diaphragm. Anteriorly it was adherent to the spleen and when an attempt was made to separate these adhesions a sharp hæmorrhage occurred. For this reason the cyst was aspirated and its contents evacuated. The cyst wall was then marsupialized. The contents consisted of daughter cysts and endocyst intermingled with purulent fluid. Two years after operation he "took a fit" in a railway train and died within 10 minutes. No post-mortem examination was made.

CASE 10. S. R., female, age 59 years, married 25 years, 6 children, youngest age 15. Patient has lived all her life in the country. Her husband is a sheep farmer. Both her parents lived over 80 years. Menstruation ceased at 46. No previous illnesses. Eight months ago patient had an attack of renal colic and pain extended from the right loin to the vulva. Pain was accompanied by slight hæmaturia. The urine was dark in color and the patient noticed in it "bladder things" about the size of a green pea. There was nothing more until 3 weeks ago when she noticed a number of similar things in the urine. Examination showed in the right hypochondrium a rounded tumor palpable on deep inspiration, which slipped back out of reach on expiration. An X-ray examination of the right kidney showed a large shadow suggestive of kidney tumor. Cystoscopic examination showed flakes of muco-pus floating in the bladder. The mucous membrane showed generalized mild cystitis. The right ureteral orifice was œdematous and swollen, the left was normal. A catheter was passed to the pelvis of each kidney

without obstruction. On withdrawing the catheter from the right side, we found a minute piece of hydatid membrane stuck in the eye of the catheter. The urine contained pus and motile bacilli. No hooklets were seen, but there was some laminated membrane. The urine from the left kidney was normal. Intravenous phthalein showed a return in 3½ minutes from the left side. No urine could be obtained from the right side. Operation was done June 23, 1916. The right kidney was exposed through an oblique lumbar incision. The kidney was occupied by a hydatid cyst and there was only a small remnant of normal kidney tissue in the extreme limit of the lower pole. An exploratory syringe was inserted into the cyst. Five cubic centimeters of clear fluid was obtained. An attempt was then made to perform a nephrectomy, but when the adhesions were separated from the under surface of the liver, a sharp hæmorrhage occurred. This was controlled by packing. The cyst was then opened and its contents evacuated from the main cavity. On digital exploration there was found a communication between the cyst in the kidney and a loculated cyst in the liver. There were three definite loculi, the first containing about 2 ounces of daughter cysts, the second about 4 ounces of similar material, and the third about 10 ounces. Much difficulty was experienced in emptying these loculi; about 1 hour was spent in trying to empty them completely with a blunt spoon and irrigation with normal saline. The patient showed signs of collapse. The operation was terminated by marsupializing the cyst wall and inserting a drainage tube.

Postoperative notes: From the wound there was a discharge of daughter cysts and hydatid débris in small quantities for about 1 week. On the eighth day there was a large gush of fluid accompanied by many daughter cysts. After this the discharge gradually lessened and the patient left the hospital 6 weeks from the date of operation, with a small discharging sinus which took 18 months to close. During the first 6 months after the operation an occasional collapsed hydatid daughter escaped from the wound. Patient remained well until after the closure of the sinus with the exception of some constant dull pain in the hepatic area. This pain was aggravated by exercise. On April 10, 1924, there was a single implantation cyst, 2 inches in diameter, in the posterior end of the scar. This was dissected completely away. When the wound was opened, no kidney tissue could be felt among the mass of scar tissue. The patient left the hospital in 1 month with the wound healed. July 15, 1925: For the past 6 months the pain in the hepatic area has become more marked. During the last 2 months there has been some shortness of breath on the least exertion, with pain in the right base on deep inspiration. The urine showed a few pus cells and motile organisms. Cystoscopy showed the bladder walls to be practically normal. Clear efflux from the left ureter, none from the right. A right pyelogram showed no pelvis present, the ureter terminated opposite the third lumbar transverse process. The liver dullness had increased upward about 2 inches in the midaxillary line. A transpleural hepatotomy was done in the right posterior axillary line. A loculated hydatid cyst of the right lobe of the liver was found, and its contents evacuated. Numerous tightly packed daughter cysts filled each loculus. On opening the pleural cavity, we found innumerable daughter cysts, varying in diameter from 26 millimeters down to 3 millimeters. No evidence of mother cysts could be obtained. There were adhesions between the diaphragm and the lower lobe of the right lung. The findings at the operation suggest that the hydatid of the liver had burst through into the pleural cavity and caused a general infection of the serous space. The patient left the hospital at the end of a month. Subsequent to her return home she developed a severe cough with an offensive sputum mixed with collapsed daughter cysts and hydatid débris. The patient died on December 28, 1925, in her seventieth year.

Case 11. A. T., male, age 41 years, married. Engine driver. Father died at 50 of tumor of the brain. Mother died at 74. Five others in the family, all healthy. He has always lived in the country. He had enteric fever at the age of 25. He has been ailing for 2 years with attacks of cramping, colic-like pain in the umbilical region of the abdomen. The pains would last for only a few minutes, would then pass off and leave a slight soreness in the abdomen. At first the attacks would come on every 2 to 3 months, but lately they have been coming every 2 to 3 weeks, are getting worse, and last longer. During the last week he has had frequency of micturition, during the day at hour and a half intervals, no nocturia. No hæmaturia at any time; no loss of weight. Examination shows a well-built, muscular man. There is an ovoid tumor in the left side of the abdomen, extending below the left hyponchondrium downward and medially into the left iliac region where it is most prominent. It is tender on palpation and has the feeling of a tense cyst. It is well felt with one hand in the right loin and the other hand in front. On tapping it we feel a slight but definite thrill. Cystoscopy shows a normal bladder with no obstruction in either ureter. A plain X-ray picture shows no evidence of stone. The left kidney shadow is enlarged downward. A pyelogram of the left side shows the pelvis normal in outline. Urine shows no albumen, no sugar; microscopically no pus, no red blood cells, no hooklets, no hydatid membrane. Blood examination showed 20 per cent eosinophilia. Complement deviation, triple positive; Casoni test, positive. A 4-inch muscle-splitting incision was made, parallel to the left inguinal ligament. The center of the incision was 3 inches medial to the anterior superior iliac spine. The cyst wall was found to be intraperitoneal. The area around the cyst was packed with gauze and the cyst wall was then opened and the contents evacuated. These consisted of endocyst and innumerable daughter cysts. The cavity of the cyst was swabbed out with

97 per cent ethyl alcohol, and was explored with the finger. No communication with the pelvis could be found. We completed the operation by allowing the wall of the cyst to collapse, and the opening in the cyst was closed with a continuous plain catgut suture. The cyst itself was then sewed to the margin of the wound, so as to anchor it. The muscles and remaining tissues were closed in layers with a rubber tissue drain at the lower angle of the wound leading down on to the closed incision in the cyst. The drain was removed in 2 days, and the wound was completely healed by first intention in 2 weeks. Patient was discharged from the hospital 2 weeks after operation. He returned to duty 1 month after leaving the hospital and worked for 9 months continuously. He had some pain at the site of the wound after a hard day's work. Ten months after operation, the wound was soundly healed, and he looked in perfect health. Urine showed no albumin, no sugar; microscopically, no pus, no red blood cells.

CASE 12. J. R., male, age 50 years, married. Water-works engineer. Father died at 41 of Bright's disease. Mother died at 48 from an aneurism. Patient lived in the country as a child. Was at sea for 10 years. Had spirochæte infection at the age of 30. Has been ailing for the last 3 months with a dull, dragging feeling in the left hypochondrium, aggravated by driving in a motor car. Seven weeks ago after a long drive he felt a lump in the left side of the abdomen for the first time. He has noticed that he gets some shortness of breath on going up stairs, no swelling of the feet. No loss of weight. Examination showed a cystic swelling in the left hypochondrium extending into the left loin. The lower margin of the swelling is on the level of the iliac crest and extends to within 2½ inches of the middle line. Urine showed no albumin, no sugar; microscopically, no pus, 1 red blood cell to a field, 1/6 objective. Cystoscopic examination showed early trabeculation of the bladder walls, no cystitis. There is early intravesical enlargement of the prostate. Differential phthalein test returned from the right kidney 6 per cent in half an hour, from the left 5 per cent in the same time. The left kidney specimen showed an occasional pus cell and red blood cells. Phthalein test gave 30 per cent in the first hour, and 10 per cent in the second, making a total of 40 per cent. Pyelogram was not taken on account of breakdown of the X-ray plant. An X-ray taken previously showed a rounded tumor in the region of the left kidney, with a protuberance from the general outline of the tumor at its lower pole. This protuberance reaches the level of the iliac crest. The lower pole of the main tumor shows an increased density suggestive of early calcification. Wassermann test, triple positive. Blood count showed neutrophils, 73 per cent; lymphocytes, 19 per cent; eosinophils, 2 per cent; transitional and large mononuclear, 0.2 per cent; basophils, 1 per cent. Complement fixation test for hydatid gave doubtful outcome. Pathological report: in view of the positive Wassermann test, the absence of eosinophilia, and the presence of leucocytosis, a hydatid infection is not suggested. A left nephrectomy was done through an oblique lumbar incision. The upper pole appeared to be normal, the lower half was occupied by a cyst more or less spherical in outline, 4½ inches in diameter. The cyst was fixed in formalin solution before being opened. It was sectioned, 1 month later, and proved to be a hydatid cyst. There was no evidence of suppuration; but it was tightly packed with daughter cysts. The wound healed by first intention and the patient left the hospital 19 days after the operation. He has been quite well and at work ever since.

CASE 13. W. D., age 30 years, male, married, builder. Patient has lived in the country all his life, but has not raised sheep for 20 years. He has had attacks of hæmaturia for the past 12 years. The first attack was colic-like in character, and the pain extended from the right loin down to the right groin. These attacks at first were at intervals of about 6 months, but lately have been more frequent. As far back as 12 years ago he passed a "little bladdery thing" in the urine following one of these attacks of pain and hæmaturia. At times he is able to trace the track of the pain down from the kidney toward the bladder region and when it reaches there he gets relief. The passage of the cysts through the urethra causes no discomfort, merely a temporary stoppage in the stream. As he is a house builder, his estimate of the size of the cysts that he has passed is probably correct. He states that he has passed cysts varying in size from ⅛ to ¾ of an inch, and when passed into a vessel they appear spherical in outline, although they emerge from the meatus in an elliptical form. The hæmaturia has been more marked of late, accompanied by clots. He estimates that in the last attack which occurred 14 days before admission, he lost about half a pint of blood. No cysts have been passed during the past 3 months. Phthalein test returned, 45 per cent, first hour; 5 per cent, second hour; total 50 per cent. Cystoscopic examination of bladder wall showed a very slight injection of the mucous membrane. Both ureters were catheterized to the pelves without obstruction. Specimen from the right side showed a trace of blood (traumatic), that from the left was slightly turbid. A plain X-ray picture of the upper tract showed an increase in the left kidney shadow. A pyelogram showed a filling defect involving the lower calyces. When the patient was examined 10 years previously by a surgeon, his attention was drawn to a lump in the left side of the abdomen, which he states has not increased in size, although he thinks that before an attack of hæmaturia comes on it gets a little larger. There has been no increase of frequency of micturition, no pain even when passing cysts. Urine shows faintly cloudy; albumin; left kidney specimen contains pus, red cells, and fragments of laminated membrane. Examination shows the lower pole of the left kidney definitely enlarged when it is felt bi-manually. Differential blood examination shows: neutrophils, 61 per cent; eosinophils, 5 per cent; lymphocytes, 30 per cent; large mononuclears, 4 per

cent. Complement fixation test for hydatid was positive; precipitin test, the serum showed slight but definite reaction. Following left nephrectomy patient had uninterrupted convalescence, and left hospital 2 weeks after operation.

CASE 14. E. W., male, age 41 years, commercial traveler, married. Father died at 50 years, cause unknown; mother died young, cause unknown. Patient paid occasional visits to the country when a child, and has traveled in the country in the course of his occupation. He has had attacks of hæmaturia for the last 6 months, at first at intervals of 6 to 8 weeks, but during the last 6 weeks has had 2 attacks. The present attack has been present for a week. The urine is sometimes bright during an attack, but more often is dark in color. No pain at any time, no increase in frequency. Cystoscopy shows bladder wall normal. Efflux from the left ureteral orifice is blood stained, no efflux is seen in 10 minutes from the right. Both ureters were catheterized to the pelves without obstruction. Specimens from the left side were blood stained, a few drops only could be obtained from the right. A plain X-ray picture showed three spherical shadows on the right side, one in the kidney area, and two in the liver area, all about 2 inches in diameter. They were typical of calcified hydatid cysts. Pyelogram was taken of the left side; it showed no definite suggestion of tumor. Urine contained faint cloud of albumin. Bladder specimen contained no pus. Right kidney urine showed no casts, no crystals, innumerable motile rods. Left kidney specimen showed findings similar except that the organisms were not present to the same extent. April 3, 1926, the hæmaturia has continued more or less continuously, but has not been present for over a week. August 17, 1926, patient has been at work ever since, no more bleeding. Microscopic test of urine showed an occasional pus cell, innumerable motile rods.

CASE 15. S. P., age 60 years, female; married 36 years; 2 children, youngest 33 years; menopause 13 years ago. Patient has always lived in the sheep district. She is subject to bronchitis in the winter time. She has had attacks of "gravel" for the past 20 years. This is accompanied by right renal colic extending from the right loin down to the right groin. There is also vomiting, frequency, and scalding on micturition. She has had attacks of hæmaturia at intervals of a few months during the attacks of pain. This stopped 3 years ago although she has still occasional attacks of "gravel." Patient states the "gravel" has consisted of a whitish sediment varying in size from a grain of sand to a piece about ⅛ inch in diameter. Examination shows a thin patient with a flaccid abdomen. The right kidney is palpable and is increased to twice its normal size. Urine shows a thick cloud of albumin; no sugar; pus cells, 6 to a field (1/6 objective). Right kidney specimen shows 6 blood cells to a field; no casts. A plain X-ray picture shows 3 distinct areas of calcification, 1 in the liver, about 1½ inches in diameter. The middle one is incomplete and the outline suggests a cyst about twice the size of a normal kidney. Within this partially calcified cyst are a number of smaller spheres about ½ inch in diameter, suggestive of calcified daughter cysts. Cystoscopic examination showed a narrow and atrophic urethra which required dilatation. The bladder wall showed mild injection of the mucous membrane. Both ureters were catheterized to the pelves without obstruction. A pyelogram was taken of the right side after 20 cubic centimeters of sodium iodide were introduced. The fluid entered the partially calcified cyst and filled it to about one-third. Urine from right kidney showed: 2 pus cells, 5 to 6 red blood cells; no casts; organisms present. From the left kidney, urine showed no pus; 5 to 6 red blood cells; organisms. Blood test showed 2 per cent eosinophilia. Casoni test gave very definitely positive reaction.

Operation was done March 21, 1926—right nephrectomy—and patient made an uninterrupted recovery, and left hospital 3 weeks after operation. January 20, 1927: Patient has been able to do ordinary housework ever since the operation. She has had no return of the attacks of "gravel."

CASE 16. A. E. S., male, age 45 years, farmer. Family history good; no previous illnesses. Present complaint is renal colic on the left side. He first noticed the trouble, which consisted of pain in the left loin, 15 years ago. The condition started with left renal colic lasting 1 week, after which he passed some gravel. He had no more trouble until 4 months ago, when he had another acute attack of left renal colic which lasted 3 days. Following this he had 3 more attacks 2 weeks ago and passed 2 small stones. He had hæmaturia during the last attack. The attacks of renal colic were typical with pain radiating to the groin, and vomiting. There was no increased frequency of micturition. Exercise did not affect the condition. Examination showed the urine to be acid, with no albumin, no sugar, 3 to 4 pus cells to a field, 1 to 2 red blood cells. Prostate was not enlarged, and showed no induration. No tenderness was present over the left kidney. Cystoscopic examination showed efflux from the left ureter very blood-stained. The left ureter was catheterized to within 2 inches of the ureteropelvic junction when an impassable obstruction was met. Plain X-ray picture failed to show any definite shadow. Four days later patient was again cystoscoped and after much manipulation a ureteral catheter was passed up to the left kidney pelvis. Urine, which was very dirty, flowed freely from the catheter. The catheter was left *in situ*, and 2 days later, patient passed an oval stone ½ inch by ¼ inch. The catheter was then withdrawn. Ten days later, without any colic, he passed a cystic mass with pus and blood. This was examined pathologically and found to be ectocysts and hydatid hooklets. The function of the right kidney having been tested and found to be quite satisfactory, a left nephrectomy was performed, and a small indurated mass could be felt in the kidney substance. This was opened and the sectioned kidney showed some small hydatids

round the middle calyx. Patient made an uninterrupted recovery, and since the operation has gained "five stone" (70 pounds).

SUMMARY

1. Hydatid is a disease of wool-growing countries. The United States and Canada are gradually coming under this classification.

2. As it takes 15 to 20 years from the time of infestation for hydatid disease to manifest itself, it will be the rising generation of surgeons of North America who will be interested.

3. There are two types of hydatid of the kidney: (a) the open type, which communicates with the renal pelvis; and (b) the closed type, which has no communication with the renal pelvis.

4. The diagnosis of the open type is comparatively easy if a full clinical and urological examination is made; but the diagnosis of the closed type is difficult and requires the aid of the intradermal test of Casoni or the complement deviation test of Ghedini.

5. Nephrectomy is the operation of choice in open hydatids. Marsupialization or nephrostomy after devitalizing the contents of the cyst with alcohol or formalin is the safest and best operation for closed hydatids.

6. Subtotal nephrectomy may prove a useful operation when the function of the other kidney is poor.

NOTE.—Those interested in the subject of hydatid disease will find full and exhaustive references to the literature in the monograph, Hydatid Disease, by Harold Dew. Australian Medical Publishing Co., 1927.

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OSTEITIS FIBROSA CYSTICA OF THE SPINE[1]

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MY reason for reporting the two following cases of osteitis fibrosa cystica of the spine is to emphasize the fact that the disease occurs in other than the long bones of the body, that trauma and infection are suggestive etiological factors, and that roentgenograms are of diagnostic value in differentiating bony tumors, and to call further attention to the value of surgical treatment in these benign giant-cell tumors.

The etiology of fibrocystic tumors or foreign-body giant-cell tumors is still debatable. Virchow, in 1876, ascribed their formation to liquefaction of chondromata; Rindfleisch, in 1886, and Hirschberg, in 1889, described these cysts as occurring in osteomalacia. Von Rechlinghausen, in 1891, described general osteitis fibrosa cystica as a diffuse, degenerating process of the long bones of metabolic origin. Beck, in 1901, described two cases of cystic disease of the tibia which he believed due to trauma. Meyerding, in 1918, emphasized the importance of infection superimposed on trauma as a probable factor in the production of fibrocystic tumors. Lewis, in 1924, on account of the clinical behavior of these lesions, expressed some doubt as to their neoplastic character and suggested the possibility of their being due to reactive tissue growth or to an attempt at repair following trauma in which excessive granulation tissue is formed; or, possibly, the lesions, in his opinion, may represent a chronic resorptive process with excessive formation of granulation tissue — not a tumor in the strict sense of the word. Ropke and Lubarsch reported finding organisms and ascribed the formation of cysts to infection, a view held by Murphy and others. Other writers as Mueller, Pfeiffer, Bloodgood, Beck, Silver, Freiberg, Murphy, Percy, Elmslie, and Heinecke have discussed the probable factors which might produce osteitis fibrosa cystica.

Broders, who made a pathological study of the tissue removed in both cases herein reported, in a personal communication, stated: "Foreign-body giant-cell tumors have masqueraded under various names, the two most common, probably, being giant-cell sarcoma and giant-cell tumor. Despite the fact that Mallery and others have called special attention to the two types of giant cells that occur in pathological processes, this distinction does not seem to be generally appreciated. The foreign-body giant cell contains a large number of small, regular nuclei, is of phagocytic nature, is not neoplastic, is closely related to the osteoclast, and, like the osteoclast, when it comes in contact with bone it absorbs it. It is found in such pathological processes as tertiary syphilis, leprosy, blastomycosis, coccidioidal granuloma, tuberculosis, chronic osteomyelitis, and giant-cell tumor of bone, tendon sheaths, and gum; it is found, also, around cholesterin crystals, blood pigment, non-absorbable suture material, colloid, keratinized epithelium, and so forth. It occurs, occasionally, in true sarcoma, especially hæmorrhagic osteogenic sarcoma.

"The neoplastic or malignant giant cell has few, large, irregular nuclei and is found, usually, in cases of highly malignant carcinoma or sarcoma. Foreign-body giant-cell tumors, when found in association with tendon sheaths, are usually yellowish, while those of bone are usually dark reddish, sometimes liver-like in appearance, although they may be yellowish. The tumors, especially those of the tendon sheaths, are rather firm, while those of the bone and gum may be semisolid. Microscopically, foreign-body giant cells may be numerous or few. Besides the giant cells there may be other phagocytes (especially the foamy cells that are filled with lipoid material) fibroblasts, fibrous connective tissue, lymphocytes, a few polymorphonuclear leucocytes, endothelial cells, numerous blood vessels and spaces, cholesterin crystals, and blood pigment. The foreign-body giant-cell tumor is of a granulating nature; however, it is not neoplastic. Because of the presence of foreign-body giant cells, it has an osteolytic property.

[1] Submitted for publication October 3, 1927.

Its cause is probably extravasation of blood, due to injury or infection."

CASE 1. A Jewish boy, aged 14 years, whose family history was negative for carcinoma, tuberculosis, and diabetes, complained of paralysis of the lower extremities at the time of admission to the Clinic and stated that he had been well until 6 months before when he experienced pain in the region of the right side of the lower dorsal spine subsequent to corrective measures advised by his gymnasium instructor for what he believed to be curvature of the spine (kyphosis). In giving a description of the pain, he stated that the whole back felt sore at times, but that there was a steady pain in the region of the lower margin of the ribs dorsally on the right, which would occasionally shoot across to the left side in a similar area. The pain affected the floating ribs, he said, and radiated around these ribs to the middle of the abdomen. In describing the pain in closer detail he said that it was neuralgic-like, was more or less constant, dull and aching, and was relieved occasionally by lying down. The pain continued without paralysis for 3 months, when difficulty in urinating, and incontinence of the rectal sphincter were noticed. Numbness over the legs and lower part of the abdomen was noticed 5 months after the onset; this soon became associated with dragging of the right leg. The weakness in the right leg advanced with the numbness, until both lower extremities became completely paralyzed and there was loss of sensation below the umbilicus and difficulty in controlling both the bladder and the bowels. Malignant tumor at the tenth dorsal vertebra had been diagnosed previously.

The patient was a fairly well nourished boy of average size for his age, and weighed 95 pounds. There was complete paralysis of the lower extremities and he had to be lifted about. The systolic blood pressure was 122, the diastolic 70. Heart and lungs were normal. Urinalysis was carried out on 2 successive days; on the latter the specific gravity was 1008, the reaction acid, and there were 12 pus cells to a field. The hæmoglobin was 74 per cent, erythrocytes numbered 4,260,000 and leucocytes 8,800. The differential count was 35.5 per cent lymphocytes, 2.0 per cent transitionals, 61 per cent neutrophiles, and 1.5 per cent eosinophiles. The combined phenolsulphonephthalein test showed a return of 30 per cent of the dye in 2 hours. The Wassermann test of the blood was negative. The pupils of the eyes were equal; the reflexes and the fields, normal; the media, clear; the ocular movements, good; and the fundi, normal. Roentgen-ray examination of the chest was negative; roentgenograms of the dorsal and lumbar spines revealed destruction of the right half of the tenth dorsal vertebra, with a more or less circumscribed shadow between the tenth and the eleventh ribs, suggestive of tumor; and multiple shadows were noted in the left renal area with calcified vertebral lymph nodes opposite the third lumbar vertebra on the right (Fig. 1). There was tenderness with rigidity over the lower dorsal spine. On neurological examination the cranial nerves were normal, as were also the brain and the spinal cord down to the tenth dorsal segment. From the tenth dorsal segment caudally, motor power was completely lost. Pain, tactile, and temperature sensibilities were impaired, being graded −3. The reflexes above the tenth dorsal segment were normal, but were exaggerated below, more so on the right than on the left. The diagnosis was obviously compression myelitis due to tumor. Because of destruction of the body of the tenth dorsal vertebra on the right, it was surmised that the lesion might be a myeloma, a giant-cell sarcoma, or a foreign-body giant-cell tumor of the osteitis fibrosa cystica type.

Exploratory laminectomy was advised and was performed August 18, 1924, under general anæsthesia. The spines and laminæ of the ninth, tenth, and eleventh dorsal vertebræ were removed. An extradural mass was exposed, which was found to involve the laminæ of the ninth and tenth right dorsal vertebræ, the transverse processes of the same vertebræ, and part of the tenth rib on the same side. The mass was definitely cystic, and the surface was composed of a shell of bone. The cavity, which extended into the bodies of the ninth and tenth vertebræ, including the intravertebral disk, was curetted and yielded reddish, pulpy, friable, clot-like material; it was not a simple hæmatoma, but was reported by the pathologist to be a benign foreign-body giant-cell tumor with hæmorrhagic cyst formation. As much of the shell-like portion of the mass as was possible was removed, and the contents of the rest of the cavity were curetted. The usual closure of the wound was made. Convalescence was uneventful, and there was evidence of slight improvement in sensation prior to dismissal at the expiration of 3 weeks. As a precautionary measure, a course of deep Coolidge-tube roentgen-ray treatment was carried out during the postoperative course. Numerous reports have been received from the boy and from his parents concerning his subsequent progress. In a letter dated January 16, 1925, it was stated that the boy had improved materially and was able to walk with the aid of crutches. June 16, 1926, a report was received to the effect that he was able to walk and to get about, and that there had been improvement in all functions but that as yet he was unable to work. The last report was received April 28, 1927, from the boy himself, in which he stated that he had been going to school and expected to be graduated from high school in June, 1927; that he was able to walk, run, hop on one leg, bend his body forward, backward, and sidewise and stand erect without curvatures; that he was free from incontinence of urine and fæces, and that there was no numbness or weakness of any sort. In other words, convalescence had been uninterrupted.

In the light of the other discussions on foreign-body giant-cell tumors of the fibro-

cystic type, this patient should continue in good health and it is unlikely that other similar lesions will develop. Probably, trauma was the important factor in the production of the lesion in this instance.

CASE 2. A girl, aged 13 years, also of Jewish extraction, was admitted November 15, 1926. The family history was negative for tuberculosis, carcinoma, and diabetes. There was a history of the usual diseases of childhood, and pneumonia at the age of 22 months, the tonsils had been removed 10 years previous to admission to the Clinic. On September 14, an exploratory laminectomy had been performed elsewhere for a tumor in the upper region of the cervical spine said to be a giant-cell sarcoma. An attempt at removal of the tumor was not made, but roentgen-ray treatment was administered.

At the time of admission the patient gave a history of tumor in the back of the neck, which she had first noticed 3 months before; there was associated pain with some tenderness, but without paralysis. On investigation, it was learned that the history dated back probably to December, 1915, when she fell from a turn-bar, striking the left side of the head and neck. She was unconscious for a few minutes only, and was able to resume her class work until noon; she did not, however, return to school in the afternoon because of pain in the head. A few days later the throat became sore and the temperature rose to 103 degrees. Tonsillitis was diagnosed and the parents were instructed to keep the child in bed for several days. For 3 days the temperature remained around 103 degrees. Convalescence from this attack of acute tonsillitis was uneventful, and she was able to return to school in 7 days from the date of its onset; except for a tired feeling in the neck, described as "the head feeling too heavy for the neck," she felt quite well. In April, 1925, after a complete physical examination, a physician pronounced her perfectly well. In June, 1926, she sustained a second injury when, while at play, a child jumped on her back; in attempting to throw the child from her shoulders, the patient twisted her neck. She said that at that time she heard a bone crack in her neck.

The patient weighed 115 pounds. There was a firm, rounded mass, slightly to the left of the median line opposite the second and third cervical vertebræ, which presented a fullness in the dorsal half of the neck. A linear scar was present along the edge of this mass, without discoloration or abrasion of the skin. The pulse rate was 81. The systolic blood pressure was 120 and the diastolic 78. Hæmoglobin was 80 per cent; erythrocytes numbered 4,700,000; and leucocytes, 8,700; lymphocytes were 41.5 per cent; large mononuclears, 7.5 per cent; transitionals, 6.0 per cent; neutrophiles, 41.0 per cent; and eosinophiles, 4.0 per cent. The Wassermann test was negative. Urinalysis of a 12-hour specimen showed a specific gravity of 1031, acid reaction, and occasional red blood cells. On examination of the eyes, vision was 6/10 on the right and 6/6 (with correction) on the left; the pupils were equal, and the reflexes and fields were normal; the examination of the fundus was negative. Examination of the ears, nose, and throat was negative. Roentgenogram of the cervical spine revealed a cyst-like tumor situated posteriorly and to the left, apparently springing from the second and third cervical vertebræ (Figs. 2 and 3). Roentgenogram of the chest was negative.

Comprehensive neurological examination failed to reveal any disturbance in either the cranial or the segmental nerves. Spinal puncture was not done. On account of the history of injury, with subsequent infection, and the shell-like appearance of the tumor brought out in the roentgenograms, I felt that it was a case of osteitis fibrosa cystica of the cervical spine and, in view of my experience in the former case in which paralysis developed, I advised exploration. This was done under combined anæsthesia, November 23, 1926, at which time I exposed and removed a rounded mass with an eggshell type of wall, arising from the laminæ of the second and third cervical vertebræ and extending along the transverse process into the body of the second cervical vertebra (Figs. 4 and 5). The tumor was more or less oval in shape and measured about 5 centimeters in its long axis, and about 3 centimeters in its short axis. It was densely adherent to the dura opposite the second cervical vertebra, producing marked compression of the dura, and displacing the cord. In order to remove the tumor, it was necessary to remove the spines and laminæ of the second, third, fourth, and fifth cervical vertebræ. Inasmuch as it was possible to resect it with the laminæ down to the transverse process, every precaution was employed to prevent injury to the cord and dura. The remaining portions of the tumor extending from the transverse process into the body of the second cervical vertebra were curetted thoroughly until nothing but a bony wall remained; this was crushed in, in an attempt to obliterate the cavity. The entire procedure was extremely bloody and the child showed evidence of profuse loss of blood. A transfusion of 500 cubic centimeters of citrated blood was given, the mother being the donor. Pathological study showed that the outer shell of this tumor was composed of fibrocystic tissue, containing spicules of bone, and that the contents were similar to those removed in the case of the former patient. The material was pulpy, of a brownish color, friable, clot-like, and contained foreign-body giant cells as well as cystic degeneration of old hæmorrhagic material and granulation tissue (Fig. 6).

Convalescence was uneventful and the patient was dismissed at the end of 3 weeks. April 11, 1927, she returned for re-examination and was found to be perfectly well. There was no limitation of motion. She did not complain of neurological symptoms, aside from sick headaches similar to those which she

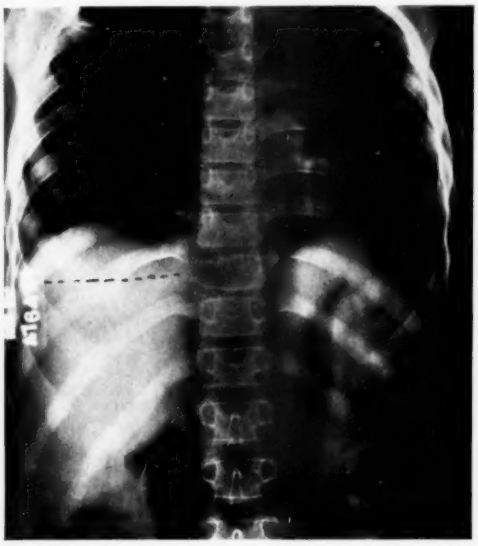

Fig. 1. Erosion of the tenth dorsal vertebra on the right.

Fig. 2. Foreign-body giant-cell tumor of the upper cervical area (anteroposterior view).

had had previous to the injury and which, apparently, were of the nature of migraine; the mother, too, is subject to migraine headaches. The cervical spine was again examined roentgenologically. There was no evidence of tumor; only slight asymmetry in the cervical spine was present.

This case is worthy of consideration since a lesion like that in Case 1 would have progressed, no doubt, until complete transverse myelitis had developed. Again, trauma and infection were etiological factors in the production of the tumor. The roentgen-ray examination was of extreme value since it demonstrated the shell-like tumor which made the diagnosis of foreign-body giant-cell tumor possible, and encouraged us to perform the second exploration.

DISCUSSION

Lewis, in reporting his case, reviewed briefly the histories of 16 additional cases, all of which were similar to the 2 I have presented. With one exception, all of the patients were between the ages of 7 and 25 years.

In attempting to differentiate foreign-body giant-cell tumor and malignant tumor of the spine, especially in children and young adults,

Fig. 3. Lateral view of tumor shown in Figure 2. The fibrocystic nature and its attachment to the second and third cervical vertebræ are shown. The shell-like appearance of the tumor and cystic areas containing irregularly placed spicules of bone are evident.

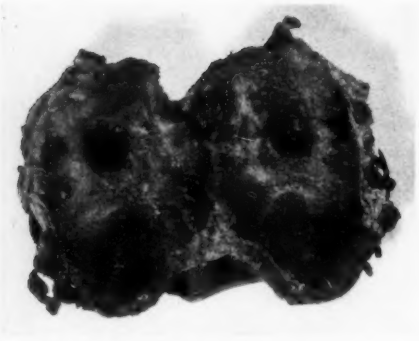

Fig. 4. Cross section of the tumor shown in Figures 2 and 3.

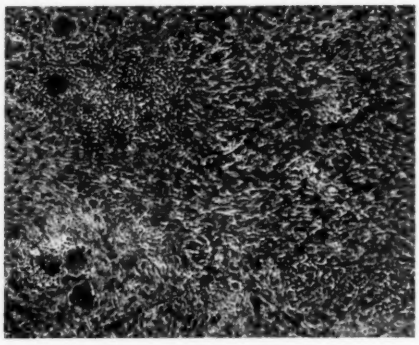

Fig. 6. Foreign-body giant cells with necrosis and hæmorrhage (section shown in Figure 4).

one must take into consideration the history of trauma and infection, and examine the roentgenograms carefully. The roentgenograms of a foreign-body giant-cell tumor will present a shell-like tumor with spicules of bone irregularly placed within the tumor presenting rarefied areas, due to the cystic formation, differing in this way from the punched-out appearance presented by metastatic lesions, from the solid enlargement of osteomata, from the radiating trabeculations of sarcoma, and from the destructive process incident to cold abscess formation in tuberculosis.

If there is doubt in the surgeon's mind concerning the diagnosis, it is well to give the patient the benefit of an exploration, since surgical removal of the tumor and relief of pressure from the cord will bring about not only restoration of function but permanent cure as well. All, or as much as possible, of the tumor should be removed and the remaining portion should be curetted thoroughly; the remainder of the wall in the body of the vertebræ should be rongeured away or crushed into the cavity, permitting the osteoblasts to restore the bony defect.

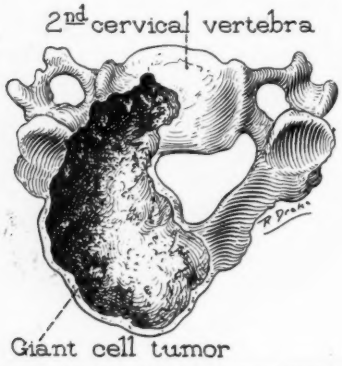

Fig. 5. Foreign-body giant-cell tumor shown in Figures 2 and 3.

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THE VALUE OF VENTRICULAR STUDIES OTHER THAN VENTRICULOGRAPHY IN THE LOCALIZATION OF BRAIN TUMORS[1]

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NO single factor is more vital to the successful extirpation of a brain tumor than precision in its localization. If the position of the neoplasm is accurately known, the operative maneuvers necessary to its removal may be carried out with a much greater chance of success. The methods of determining that region of the brain involved by the tumor are many and varied. A careful detailed history with the chronology of the onset of the symptoms plus routine neurological studies, retinoscopic examinations, and visual perimetric tests, coupled with vestibular studies and roentgenoscopic films will furnish in the majority of instances clean-cut evidence of the site of the neoplasm. However, in a certain number of cases, although the presence of a tumor is unquestioned, no definite clue can be obtained as to its situation. Heretofore, to solve this problem of the unlocalizable brain tumor, a ventriculogram was necessary. But as experience with ventriculography increased, the effect upon the size, shape, and position of the ventricles of tumors placed in different brain areas became more clearly appreciated. It soon became apparent that if a definite routine were adopted in the tapping of the lateral ventricles, the estimating of the amount of fluid removed from each and the determining by injection of a dye whether the interventricular foramina were patulous, a very shrewd guess could be made as to the abnormality in the ventricular outline that the X-ray films would subsequently reveal. This procedure of attempting to determine the position of the lateral ventricles by plunging for them from a fixed point, of estimating their relative size by the amount of fluid recoverable from each, and lastly, of discovering whether or not the interventricular foramina are patulous by the injection of a dye has been termed by Dandy (1) ventricular estimation. It is a logical outgrowth of his brilliant conception of cerebral pneumography. Since bilateral ventricular tap without the replacement of the fluid by air is unquestionably safer than ventriculography, this has seemed sufficient justification to attempt to discover the value and the limitations of this less hazardous method of tumor localization.

Four conditions must be met in order to draw accurate conclusions from ventricular estimation. It is necessary to appreciate clearly the effect upon the ventricular system of a tumor in different regions of the brain. The operator should be thoroughly familiar with the normal position, size, and depth from the surface of the lateral ventricles so that he can be certain that a failure to reach either of them is due to an abnormality in their outline and not to an error in his technique. The patient must be sufficiently co-operative to permit of a complete neurological study, so

[1]From the Neuro-Surgical Clinic of Dr. Charles H. Frazier, University Hospital, Philadelphia.

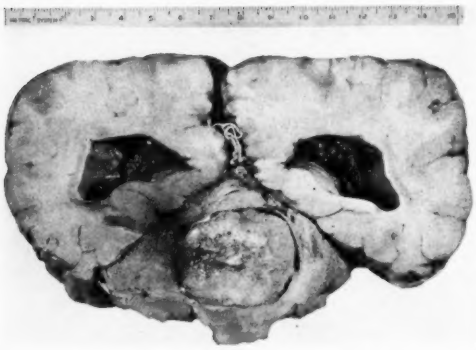

Fig. 1. Necropsy specimen showing the effect of a cerebellar tumor on the ventricles. Note the marked symmetrical hydrocephalus.

that by obtaining normal responses from the different brain areas it can be determined which of them, because of their unimpaired function, are obviously uninvolved by the tumor. Lastly, the possibilities of error inherent in this method must be grasped so that, if necessary, air may be introduced to outline the ventricles accurately if the evidence from an estimation alone seems inconclusive.

Broadly considered, brain tumors produce two types of changes in the ventricular system —symmetrical or asymmetrical variations in the size, shape, and position of the lateral, third, and fourth ventricles. Symmetrical dilatation of the lateral ventricles is always due to an internal hydrocephalus set up by a tumor obstructing the free circulation of the cerebrospinal fluid. To produce such an effect, a tumor must be situated in the midline between the cerebral hemispheres either in or impinging upon the third ventricle supratentorially or in the posterior fossa (Fig. 1). Ventricular estimation under these circumstances would reveal the lateral ventricles in normal position or nearer the cortex than usual. Both ventricles should show an increase in fluid content to approximately the same degree. Dandy states that it is necessary to obtain at least 30 cubic centimeters of fluid by free flow or aspiration from each ventricle to be safe in inferring that a hydrocephalus exists.

It is particularly in cases of hydrocephalus that injection of indigocarmine dye into one lateral ventricle may give important information. If, under these conditions, this indicator be injected into one lateral ventricle and cannot be recovered from the other, this is good evidence that the interventricular foramina are obstructed and that the tumor lies in this region.

Asymmetrical variations in the ventricular outline are always due to a tumor lying within one cerebral hemisphere and causing a shift in the position of one or both lateral ventricles with filling defects in the outline or even complete obliteration of the ventricle lying within the hemisphere involved (Fig. 2). Such changes are due to direct pressure from the neoplasm and not to secondary effects from interference with cerebrospinal fluid circulation. Under these conditions it may be impossible to introduce the exploring cannula into one or the other lateral ventricles. If both can be tapped, the ventricle on one side contains much more fluid than its fellow—definite evidence of their inequality in size.

The ventricles should always be tapped from the same relative position. It is only through the development of an accurate technique in

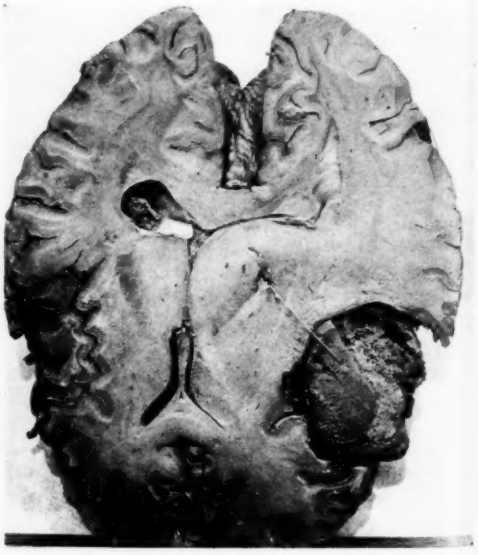

Fig. 2. Necropsy specimen showing the effect of cerebral tumors on the ventricles. Note the asymmetry of the lateral ventricles.

introducing the cannula that positive evidence of changes in their position may be determined. Bilateral trephine openings are made 7 centimeters above the occipital protuberance and 1.5 centimeters lateral to the midline to avoid the longitudinal sinus. The cannula is directed to enter the vestibule of the lateral ventricle, its widest point. The occipitoparietal approach is used because the cannula passes through a relatively silent cerebral area, well behind the sensory cortex, and above the visual tracts. From this position the ventricles should be encountered at a depth of from 4 to 5 centimeters, the cannula being directed slightly outward and in a horizontal plane, level with the tip of the ear. A shift in the position of a ventricle may be demonstrated by variations from these normal planes necessary to enter it with the cannula.

A complete neurological examination performed upon a co-operative patient is necessary to obtain the most accurate results from ventricular estimation. The negative evidence

Fig. 3. Tumor removed from Case 1.

Fig. 4. X-ray of Case 2, one year post-operatively after retapping of the cyst and replacing the fluid with air. The position of the cyst in the left frontal lobe is clearly shown.

of unimpaired functions from various cortical areas demonstrating that they are probably not involved by the tumor must always be considered. For example, if it can be shown definitely that one lateral ventricle is much smaller than the other, obviously the tumor cannot be cerebellar or in the third ventricle because a symmetrical hydrocephalus does not exist. The neoplasm must lie in that cerebral hemisphere harboring the smaller ventricle. And if all the active cortical areas of that hemisphere function normally the tumor must be located in a silent area, for example, the frontal lobes or the right temporal lobe.

In many instances where the clinical evidence is open to more than one interpretation as to the location of the tumor; for example, when doubt exists as to whether the lesion is in the frontal lobes or cerebellum, ventricular estimation may clear up the situation at once by determining the presence or absence of hydrocephalus. Once it is known whether the tumor lies above or below the tentorium the proper localizing symptoms may be stressed while the confusing signs can be confidently rejected.

In a series of 26 cases in which ventricular estimation had been employed as an aid in diagnosis, 19 were subsequently verified at operation or necropsy. Our interpretation of the findings was correct in 18 instances, incorrect in 1 instance. One death occurred in a patient already stuporous from high intra-

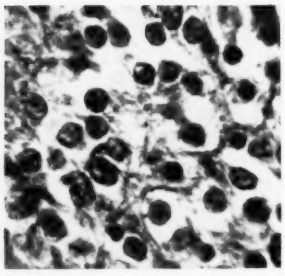

Fig. 5. Photomicrograph of a section of the tumor removed from Case 2. H and E stain. ×850.

Fig. 6. Photograph of the tumor which was removed from Case 3.

cranial pressure due to a large infiltrating glioma.

The 3 following cases are illustrative of the value of ventricular estimation. That these 3 cases should all have harbored frontal lobe tumors is not a matter of chance. The frontal lobes are silent brain areas. Lesions in other regions of the cerebral hemispheres usually produce definite clinical symptoms which make localization possible by ordinary methods.

CASE 1 presented a confusing neurological syndrome, although the presence of a tumor was unquestioned. The left ventricle could not be tapped, but the right ventricle was easily reached. Operation consisted of a left frontal craniotomy with removal of large endothelioma arising from left olfactory groove. The patient recovered.

M. B., a farmer's wife, 42 years of age, was admitted to the Neuro-Surgical Service of the University Hospital on March 23, 1927. She was referred by Doctor Long, of Statesville, North Carolina. Her chief complaint was failing vision and headache. Until March, 1926, she had been perfectly well. At this time she had a sharp attack of influenza and was in bed for 2 weeks. She noticed that she was very sleepy. When she left her bed she felt weak, noted a diplopia, and her left eye turned outward. A sharp, severe pain developed behind her left eye lasting at times 3 or 4 days. This pain was accompanied by projectile vomiting. These attacks of pain and vomiting came on about every 2 weeks with increasing severity. In September, 1926, the headache shifted occasionally during an attack to a point behind her right eye as well. There was a steady loss of vision in her left eye with complete loss by September, 1926, while the sight in her right eye also steadily deteriorated. At this time she noted complete loss of her sense of smell. Tinnitus developed in her right ear with diminution in auditory acuity. During September she had two transitory attacks of facial weakness on the right side. Since this time the headaches in the frontal region have increased in severity. At the present time she has constant frontal headache behind both eyes; complete loss of vision in the left eye and only light perception in the right; complete bilateral anosmia; continuous tinnitus, and decidedly impaired hearing in her right ear.

Physical examination revealed a fairly intelligent and co-operative white woman, almost totally blind, and rather inclined to make light of her condition. Externally her head was normal. There was no evidence of endocrine disturbance. There was a complete bilateral anosmia. The left eye was totally blind; light perception alone remained in the right. Both retinæ showed receding choked disc with marked atrophy possibly more marked on the left than on the right. The extra-ocular movements were normal as was sensation in the face and movements of the lower jaw. There was a slight weakness of the right seventh especially about the angle of the mouth. There was a definite loss of auditory acuity with tinnitus in the right ear and a slight weakness of the right palate and right tongue. The remaining cranial nerves were normal. Cerebral function was normal except for an unexpected cheerfulness and a questionable memory defect. Motor and sensory functions were normal throughout. Astereognosis, sense of position, and vibration were normal. Visual field tests could not be performed.

There was noted a slight but definite inco-ordination of the left hand and leg. Her gait was uncertain with staggering to the left and she could not stand in the tandem position. Rhomberg's sign was present. There was questionable suboccipital tenderness. No nystagmus was reported.

X-ray studies showed a depression of the floor of the pituitary fossa and atrophy of the dorsum sellæ. This condition could be due either to suprasellar tumor or dilated third ventricle. Lumbar puncture showed a spinal pressure of 36 milligrams of mercury. A diagnosis of left frontal or right angle tumor was made.

To settle the disputed point concerning the position of the tumor, Doctor Grant performed a ventricular estimation on May 1, 1927. Bilateral trephine

openings were made over the vertex. The left ventricle could not be reached. The right ventricle was readily tapped and 20 cubic centimeters of fluid were obtained. The left ventricle was, therefore, obliterated, asymmetrical lateral ventricles existed, and the tumor could not be located in the posterior fossa. A left frontal craniotomy was, therefore, performed and a large meningioma (Fig. 3) arising from the left olfactory groove was removed. Convalescence was uneventful. Sufficient vision was regained in the right eye for the patient to see to thread a needle.

It is in the differentiation between subtentorial and supratentorial tumors that ventricular estimation is of especial value. Once ventricular asymmetry has been determined the tumor is known to lie above the tentorium.

CASE 2. Marked evidence of intracranial pressure without definite localizing signs. A ventricular tap showed that the left ventricle was obliterated. A left frontotemporal flap was turned back and a gliomatous cyst was exposed and evacuated.

R. B., a Jewish housewife, was referred to the University Hospital on July 2, 1925 complaining of weakness and loss of vision. She had been entirely well until December, 1924, when she began to suffer from very severe frontotemporal headaches. Early in 1925, rapid failure of vision followed. In March, 1925, a right subtemporal decompression was done at another hospital in an attempt to preserve vision. Following this procedure, the headaches disappeared but the visual loss steadily progressed. There has been no evidence of motor loss or convulsions, but 6 weeks before admission a transient attack of unconsciousness occurred. There was some mental deterioration with a thick uncertain speech and drooling of saliva. During the preceding week she had become much weaker and had difficulty in getting about. Her gait while weak had never shown any suggestion of staggering. She had much difficulty in swallowing solid foods.

Physical examination revealed an undernourished woman, rather unco-operative and silly in her talk. Her gait while weak was not abnormal. No Rhomberg sign was noted. Her memory was much impaired. The speech was rambling and occasionally disjointed but the presence of actual aphasia seemed questionable. There was a fair-sized, tense hernia cerebri on the right. The cranial nerves were negative except for questionable bilateral loss of sense of smell, occasional lateral nystagmoid movements of the eyes in both directions, and bilateral choked discs of 5 diopters. The form fields were full to rough tests. The extremities revealed uniform weakness without sensory loss. No dysmetria, ataxia, adiadochokinesia or astereognosis could be demonstrated. All reflexes were equally exaggerated. A bilateral Babinski, Oppenheim, and abortive ankle clonus were noted. The roentgen-ray studies were negative. A diagnosis of cerebral tumor was made but with uncertainty as to laterality.

Fig. 7. Ventriculogram showing the effect of the tumor *T* of the left lateral ventricle on the ventricular system. Ventricular tap alone under these circumstances would have led to error in diagnosis because symmetrical hydrocephalus would have been found and a subtentorial lesion suspected. Localization of the tumor was determined by ventriculography and verified by the removal of the tumor at operation.

Doctor Grant attempted a bilateral ventricular tap through the parieto-occipital approach on July 8, 1925. The right ventricle was found to be in a normal position and contained 24 cubic centimeters of fluid. The left ventricle was reached but only 2 cubic centimeters of fluid could be obtained. Pressure over the hernia cerebri seemed to increase the flow from the right ventricle but not from the left. *Impression*—asymmetry of lateral ventricles with obliteration of left; tumor in silent area of left cerebral hemisphere.

On July 14, 1925, a left frontal flap was reflected revealing a large gliomatous cyst. An evacuation of the cyst (Fig. 4) was carried out with treatment of cyst wall with Zenker's fluid and removal of part of the deep lying tumor for pathological identification. This was followed by a decompression at the base of the flap. The patient recovered and was discharged. A pathological diagnosis of oligodendroglioma was made (Fig. 5).

The first real clue to the position of this tumor was furnished by ventricular estimation. The relatively marked difference in the size of the ventricles was clear evidence that the tumor lay in the left cerebral hemisphere compressing the left lateral ventricle. Since the neurological signs were so few, the neoplasm was known to lie in a relatively silent area of the brain. The frontal region seemed almost certainly the seat of the tumor for the visual fields, although of very questionable value, appeared full and, furthermore, in performing the tap in the parieto-occipital region no sense of resistance to the exploring needle suggesting a tumor was encountered. By the process of exclusion the neoplasm was considered to be in the left frontal lobe.

CASE 3 was characterized by the sudden onset of occipital headache and loss of vision. No localizing clinical signs were elicited although marked evidence of intracranial pressure existed. Ventricular estimation localized the tumor in the right cerebral hemisphere. A right frontal flap was made and the tumor extirpated. The patient recovered.

A. F., white, 27 years of age, a chauffeur, entered the University Hospital on November 3, 1926, referred to us by Dr. Samuel Leopold. The chief complaints were occipital headache and dimness of vision. The headaches had increased markedly in frequency and were accompanied by dizziness. As the headaches developed the patient noted a definite loss in visual acuity. One week previously the headaches and visual loss became so severe that he was forced to stop work. There had been no other symptoms.

Physical examination revealed a young, white, adult male of fair development and intelligence. He was co-operative. He placed his hands on the back of his head and complained of severe pain in this region. The cranial nerves were negative except for the eyes which showed a pupillary irregularity, the right pupil being larger than the left. A choked disc of 4 diopters in the right and 3 diopters in the left eye was noted. There was a subjective blurring of vision although the visual fields were essentially normal. A very questionable right lower facial weakness was noted. No aphasia, apraxia, astereognosis, or adiadochokinesia could be demonstrated. He complained of dizziness on sudden change of position, suboccipital tenderness, and slight uncertainty in gait, but no other cerebellar signs could be elicited. There were no abnormalities in the reflexes. The left lower leg seemed definitely less well developed than the right. The serology was entirely negative. Roentgenograms of the head were negative. There was a marked bilateral axillary adenopathy. During his stay in the hospital, the headache localized itself definitely behind the right ear. Closer questioning revealed a clear cut memory defect, but no alexia or agraphia could be demonstrated. A questionable weakness of the left arm was noted by one observer. *Impression*—Brain tumor unlocalizable, possibly in the posterior fossa.

A ventricular tap made on November 29, 1926, by Dr. Grant, showed that the left ventricle contained a few drops of fluid while the right could not be entered. A right frontal flap was then reflected and a tumor springing from the dura and involving the upper anterior portion of the right frontal lobe was found and removed. The patient recovered. A pathological diagnosis of meningioma was made (Fig. 6).

Here again the question of the localization of the tumor below or above the tentorium was solved by ventricular estimation. Furthermore, the tumor was located in the right cerebral hemisphere. As all of the active areas of this hemisphere gave normal responses the neoplasm must of necessity have been situated in a silent area—the right frontal lobe.

In order to evaluate properly the usefulness of any test, its limitations must be clearly understood. Ventricular estimation may easily lead the surgeon into error unless certain facts are taken into consideration. If ventricular asymmetry can be surely demonstrated, this is certain evidence of a cerebral hemispheric tumor situated on the side of the smaller ventricle. If the ventricles are undilated, equal in size, and normal in position the lesion is *probably* not cerebral. It may be a cerebellar tumor which has not obstructed the cerebrospinal fluid circulation sufficiently to cause hydrocephalus. At times the posterior horns of the lateral ventricles may be absent as pointed out by Penfield (2). This may be deceptive for the ventricle apparently lies deep in the hemisphere and may seem undilated even though a moderate hydrocephalus exists. We have observed a case in which a cerebellar tumor was ruled out because absence of the posterior horns led the operator to believe that no hydrocephalus was present. A ventriculogram later corrected the error and demonstrated a fair degree of bilateral hydrocephalus with absence of the posterior horns. An angle tumor was later successfully removed.

If hydrocephalus exists, it is wiser to perform a ventriculogram and attempt to localize the tumor exactly unless the clinical evidence is overwhelmingly in favor of a posterior fossa lesion. The accompanying roentgenogram

(Fig. 7) shows the hydrocephalus produced by a tumor lying within the left lateral ventricle. Had only an estimation of the size of these ventricles been made, the conclusions based upon the test would have been grossly misleading. Furthermore, the differentiation between midline supratentorial and posterior fossa lesions is not possible by bilateral tap alone, for both produce symmetrical hydrocephalus. The only method by which this distinction can be made is through air injection and a determination of the presence or absence of air in the third ventricle. Furthermore, this differentiation is of importance because the operative approach to the two regions is so radically different.

In any intracranial procedure, release of intradural tension by ventricular tap will reduce hæmorrhage and make possible a proper approach to the lesion, thus greatly facilitating its extirpation. It is always a wise precaution, therefore, to know something of the size of the ventricles before attacking any tumor no matter how positively its position may be known. Furthermore, if in a suspected cerebellar case, a tap for relief of pressure fails to demonstrate a hydrocephalus, the operator must be very certain of his ground on clinical or other evidence before he explores the posterior fossa, for in the presence of increased pressure, cerebellar tumors always cause hydrocephalus.

CONCLUSIONS

1. Ventricular estimation is a safer procedure than ventriculography. In experienced hands with proper interpretation it may often give information of equal value.

2. Asymmetry of the lateral ventricles is very strong evidence of a cerebral tumor on the side of the smaller ventricle.

3. A symmetrical hydrocephalus usually indicates a cerebellar tumor. However, it is under these circumstances that an error may be made from ventricular estimation alone unless the clinical syndrome points to the cerebellum. If doubt exists it is wiser to perform a ventriculogram in the presence of hydrocephalus.

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CLINICAL SURGERY

FROM THE CHICAGO LYING-IN HOSPITAL

THE TREATMENT OF OCCIPUT POSTERIOR POSITION AFTER ENGAGEMENT OF THE HEAD

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IN a short article on technique it is not possible to cover the whole subject of the treatment of occiput posterior position, and therefore I have selected one phase of it, the most common one: what to do after the head has engaged in the pelvis but anterior rotation of the occiput has failed to take place, indeed, the occiput may have turned further backward after descent, and has come to rest in the hollow of the sacrum, with the small fontanel in the median line.

In order to lend a little scientific precision to our description of the various positions the presenting part occupies in the pelvis, I have recommended that we name these positions according to the degrees of a semicircle, the zero point being the pubis. Thus when the occiput lies, as just described, we would term it an occiput 180 degrees, right or left, depending on which side the occiput came down. Occiput right transverse would be O.D. 90 degrees; occiput left anterior, O.L. 45 degrees, etc.

As a rule in practice we find that a head which comes into the pelvis O.D. 135 degrees or O.L. 135 degrees (i.e., O.D.P. or O.L.P., respectively) will, if given time enough, rotate spontaneously the rest of the half circle and come to lie O.D. 5 degrees, or O.L. 5 degrees, or 0 degrees, whence it will be delivered spontaneously or by the aid of a simple forceps operation. Since this may require many hours of labor, the accoucheur should support the parturient's powers with food, especially sugars and fluids, and with rest and sleep. Morphine and scopolamine, morphine and magnesium sulphate, with or without oil-ether rectal instillation, are to be used generously. The bag of waters must be preserved as long as possible and ruptured only after complete dilatation of the cervix has been obtained. There are exceptions to this rule but they are rare. The patient should lie mainly on the side to which the occiput points but should change often. The rectum and bladder are to be kept empty.

Slow dilatation of the cervix may be due to primary inertia of the uterus, or to abnormal action of the uterine muscle, e.g., the formation of contraction rings and strictures. These must be differentiated. The treatment of course varies. In the one we will stimulate, in the other tranquilize the uterus. Early in the first stage a dose of castor oil with 3 to 5 grains of quinine may be given. The nasal application of pituitary extract according to Hofbauer's method may be tried, but the accoucheur must stand ready to remove the packing and give ether at once, when the pains get too strong and endanger the mother or child. I seldom employ this remedy. Narcotics are the best for strictura uteri; they may be aided by atropin in physiological dose.

In the olden time we obtained much benefit from the following procedure: the parturient was given a hot bath (now superseded by a hot wet pack), then a generous alcohol rub, then an enema of 30 grains of bromide of soda, and 15 grains of chloral; then a drink of hot lemonade; finally 1/6 to 1/4 grain of morphine; the room was darkened and quieted. A refreshing sleep lasting 6 to 10 hours usually resulted and dilatation, as the result of insensible labor, was often found nearly complete when the pains began again.

Should medical treatment fail, the dilatation of the os can be hastened by packing the cervix and vaginal vault with gauze saturated in glycerine to which ½ per cent mercurochrome has been added, or by metreurysis.

Let us say that the parturient has been carried to the point where the cervix is completely dilated, or to a diameter of 8 or 9 centimeters and by means of Duehrssen's incisions the opening can be safely enlarged to permit extraction of the child. Now what to do?

First one must be convinced from the character of the labor up to this point that the woman will not be able to end the process herself. It is well to be prepared for surprises, as occasionally the head

flexes, the pains strengthen, and rotation of the occiput to the front takes place rapidly. If the patient merely changes her position in bed, or gets up to go to the toilet, this favorable mechanism may be started.

Beyond question it is better for the mother and safer for the baby to have anterior rotation of the occiput take place and the birth occur with the usual anterior mechanism. This statement is made though I am well aware that a certain percentage of cases of occiput posterior terminate as such spontaneously with the small fontanel coming out over the perineum, and also that a certain number of accoucheurs do not believe in effecting anterior rotation before they attempt delivery. Only when our attempts to correct the abnormal position fail do we consent to deliver the occiput over (usually through) the perineum.

The methods of dealing with persistent occiput posterior positions are numerous: Hodge's maneuver consisting of upward pressure on the synciput during the pains; Tarnier's maneuver, the attempted rotation of the head with the fingers which obtain a purchase behind the ear; the same aided by backward pressure on the cephalic prominence above the pubis (the forehead); rotation of the head in the pelvis by combined manipulation under an anæsthetic, the whole hand being used internally; the pushing of the head up out of the pelvis and the rotation of the whole fetal body by twisting the child's trunk to the opposite oblique; podalic version; the use of the forceps as a rotator, or as combined rotator and deliverer.

In the majority of cases it is possible to turn the head in the pelvis by means of the hands, at least so far as to bring the small fontanel from the hollow of the sacrum, O. 180 degrees, into an anterior quadrant of the pelvis, O.L. 45 degrees, or O.D. 45 degrees. Then one can easily finish the rotation and the delivery with forceps.

With the patient under deep anæsthesia, the whole hand is inserted and the head is gently lifted up out of its imbedment in the soft parts. It makes little difference which hand is used inside the pelvis, though in O.L.P. I usually put the left hand in, behind the pubis and press backward on the forehead lying there, with the fingers, or, if it seems easier, I twist the wrist so as to insinuate the fingers underneath and behind the occiput lying on the left side, the thumb pressing on the side of the forehead. By the supinating of the hand the head is turned into the transverse. Now the fingers are quickly withdrawn part way, the hand reversed so as to bring its dorsum behind the pubis, the fingers resting on the malar bone

Fig. 1. Changing a right occiput to an anterior position by combined manipulation.

and by a supinating movement, pressure on the forehead is exerted sweeping this part of the head through the right half of the pelvis toward the sacrum. Thus the occiput comes to lie near the pubis. This maneuver succeeds best when the head is partly deflexed. When flexion is well established it may be (it is not always) better to work on the occiput directly.

In O.L.P. (O.L. 135 degrees) with flexion, the right hand is laid behind the head with the volar side of the fingers upward, and by a pronating twist of the wrist combined with flexion of the fingers the occiput is levered to the front. All the movements are aided, abetted, modified, and controlled by the outside hand and the turning of the head is made easier by lubricating it and the vagina with green soap (Fig. 1). It is also advisable to have the head of the patient 3 or 4 inches lower than the pelvis in order to prevent prolapse of the cord when the fetal head is raised up.

One is often disappointed to find that after the head has been turned into an anterior sector of the pelvic circle, before the forceps can be applied, indeed often before one withdraws the hand, the occiput slips back into its former malposition. There are several ways of handling such a situation: (1) have the assistant by a hand above the pubis press the forehead backward and hold it while you apply the forceps (not very successful); (2) have him try to turn the baby's back anteriorly, or indeed a little beyond the midline and press down on the fundus, to favor flexion, etc. (also not very successful); (3) the operator can, after turning the head as far as it will go, withdraw his hand and neatly slip in the other one behind the pubis to press the forehead back; (4) he may

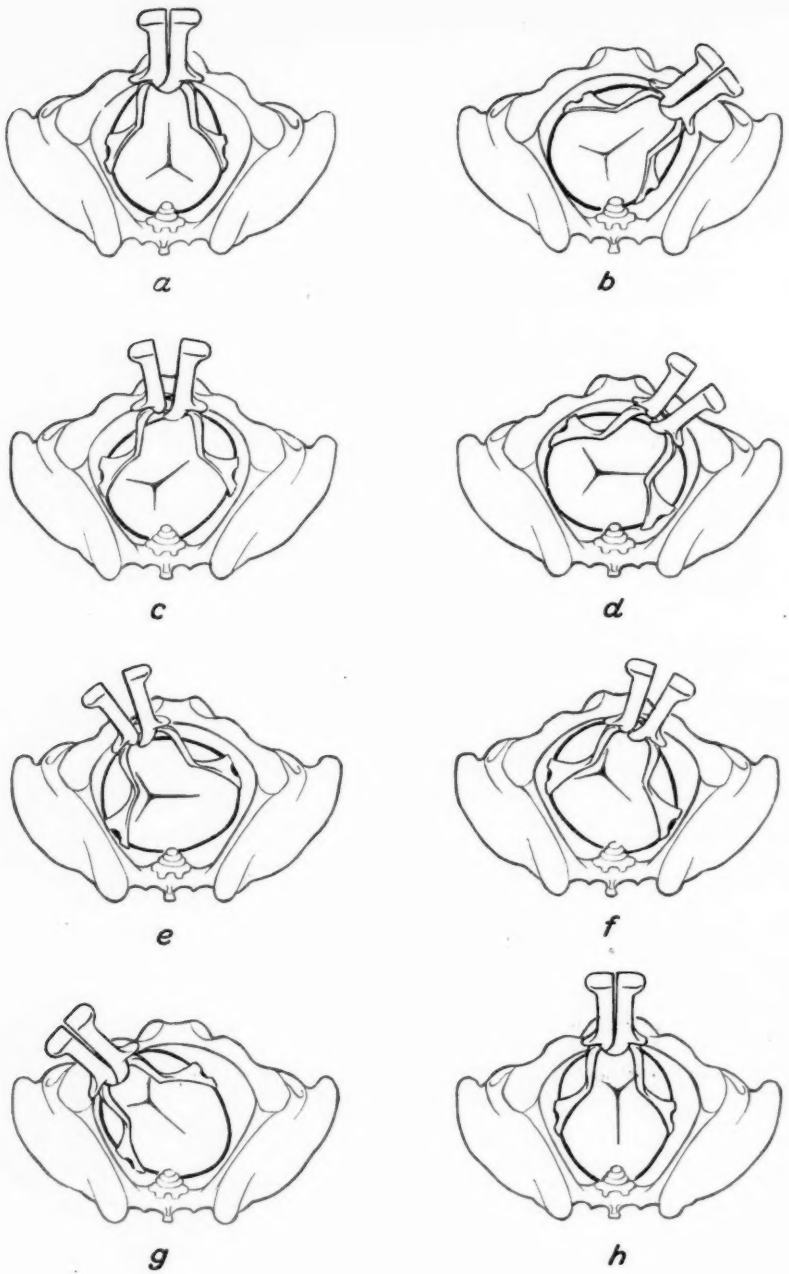

Fig. 2. The successive stages of forceps operation in occiput right posterior, O.D.P., which has become an occiput sacral, or O.180 degrees. The "key in lock" maneuver is being practiced and as the occiput turns anteriorly the forceps' blades are carefully readjusted.

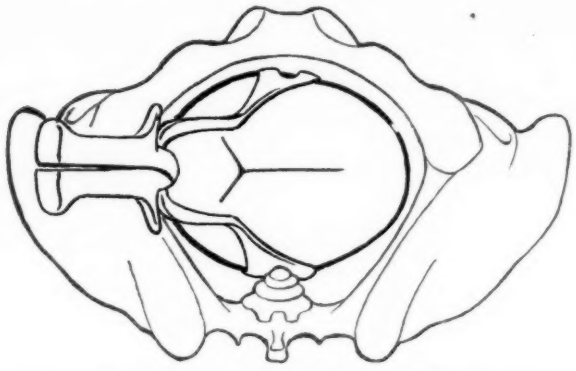

Fig. 3. Forceps applied to the head, O.D.T. (O.D.90 degrees) with the blades in the anteroposterior diameter of the pelvis. The head is grasped ideally but there is danger to the mother's soft parts.

use the hand which effected the rotation internally, to hold the head at the point of rotation gained until one blade of the forceps can be applied and this, acting like an old fashioned vectis will keep the head in its new position or indeed may increase the rotation; (5) he may fix the head at the furthest anterior point of rotation by means of a vulsellum attached to the baby's scalp. He should be sure not to try to turn the head with this instrument, it will tear out a piece of skin,—merely hold the head steady with it,—thus employed, no harm will result.

Should manual rotation fail, which very seldom happens if one goes about it *lege artis*, resource must be had to the forceps. Let me repeat, this article deals with the abnormal position *after* engagement. Before the head has sunk below the inlet, version is usually the choice. The operation of forceps in persistent occiput posterior positions may be very easy and very hard. Much depends on individual skill and considerable also upon the conformation of the pelvis and soft parts and the size of the baby and pelvis.

At the very outset of the discussion of forceps in occiput posterior positions we meet this question. May the forceps be used as a rotator or is it to be simply a tractor, adding to the downward movement of the head only that amount of rotation which nature gives the head in its passage, its progress being thus made a turbinal motion?

Levret, in 1746, said that the forceps should be a tractor and nothing else, to supply from below the force that was lacking from above. Smellie, in 1752, used his short, straight forceps as a rotator; Scanzoni, in 1865, developed an operation in which instrumental rotation was the main feature. Tarnier, in 1881, demonstrated the principle on which the forceps may be used to correct the position of the head in the pelvis. He pointed out that, because of the pelvic curve of the instrument, if one twists the handles, the blades, with the head in their grasp, do not turn on the axis of the shanks, but tend to describe part of a circle within the pelvis. In order, therefore, to make the head rotate around an axis, it is necessary to sweep the handles of the forceps through a large circle outside the pelvis. The apex of the forceps blades then will act as a center and the head will turn around on it. Bill has improved on Tarnier's maneuver by first raising the head out of the pelvic floor gutter, and then sweeping the handles around to impart the movement of rotation to the head within the pelvis. Kielland, in 1915, devised a forceps without pelvic curve, and with the blades bent a little downward. With this instrument a head may be grasped biparietally, no matter in which diameter it lies in the pelvis and it may, according to Kielland, be twisted safely to any position desired.

The dangers of using the forceps as a pure rotator, as Scanzoni and Tarnier did, are: the vagina and bladder may be torn from their attachments to the fascia and the bony pelvis; hæmatomata may be produced in the areolar tissue at the bases of the broad ligaments; the ureters may be stretched; and the baby's head and neck may suffer damage. If the head is pushed up too far, the cord may prolapse necessitating a hurried, forceful, and destructive extraction. With these things in mind I have devised a method of rotation of the head which combines several of these well known maneuvers, and for want of a

better term I have named it the "key in lock" operation. It really tries to imitate nature's process of push, twist, retract, untwist, and repeat, but we have to do them in reverse—push up, twist, pull, and repeat. We try to impress a wriggling motion on the head, which is not easy to describe.

With the head lying in the right oblique diameter, O.D. 135 degrees, the forceps blades are laid in the transverse of the pelvis. They will grasp the head diagonally, in an unfavorable manner, and are, therefore, to be held very delicately. Now, under the slightest possible compression, the head is pushed up about 2 centimeters in the axis of the birth canal and gently twisted, the small fontanel being brought forward not more than 5 degrees. This is done by sweeping the handles of the forceps through an arc of about 10 degrees outside the pelvis *à la methode Tarnier*. Then the head is pulled down a little in the axis of the pelvis, but less than it was pushed up. Repeat this maneuver two or three times, pushing the head up only as much as you pull down, and when the sagittal suture is transverse, i.e., O.D.T. or O.D. 90 degrees, the front of the forceps will now point to the left, and they will lie in the left oblique. Readjust them so that they will come to lie in the right oblique, grasping the head in a more favorable diameter, that is, the ideal manner. Indeed, sometimes the head slips around the rest of the way itself within the blades. By pushing up a little, twisting a little, and levering a very little (to overcome asynclitism), imparting a wriggling motion to the head not unlike fitting a key into a stubborn lock, one can usually coax the occiput to the front, whereupon the rest of the operation—the extraction, is completed without trouble. One should not hurry nor do too much turning at once, not more than 5 degrees; it is like taking mincing steps. Readjust the forceps *pari passu* as the rotation is effected (Fig. 2, A to H).

The prehension of the head at the beginning of this operation need not always be made as described. Variants must be recognized, but the principle does not change. Sometimes it is possible to lay the blades to the head anteroposteriorly in the pelvis with their front directed toward the small fontanel (Fig. 3). Again one may apply the forceps with the front toward the forehead (as in the Scanzoni maneuver), and when the occiput is brought into the anterior quadrant of the pelvis, remove them and reapply as for an anterior position.

In rare cases it is impossible to turn the occiput to the front either by manual effort, or by the forceps, or by a combination of the hands with the forceps. To force the issue would entail great damage to the mother and probably kill the baby; therefore we must observe and discover the mechanism intended by nature and then aid it. If the occipitosacral mechanism is inevitable, it is best to deliver the head in extreme flexion.

The application of the blades is made as usual, but the front of the forceps looks toward the forehead, which, from now on, becomes the point of direction. Locking the blades is the same as usual, but after they are locked the handles are raised a little toward the pubis in order to increase flexion. Traction is made on the parietal bosses, a little upward from the horizontal plane. This increases flexion, and it has happened, though I have never observed it, that, even as late as this, anterior rotation has occurred. The occiput is first delivered over the perineum, the forehead resting behind the pubis; then the brow and face come from under the pubis. Much power is often necessary, and it is advisable to perform episiotomy in primiparæ, as a rule, and almost always in multiparæ, to avoid extensive lacerations of the pelvic floor and sphincter. If conditions are favorable one might deflex the head and deliver as a face presentation. These cases are claimed by the Kielland forceps enthusiasts. Some accoucheurs prefer the axis traction forceps since the mobility they confer on the head allows the latter to adapt itself somewhat to the parturient passage, but for the man who knows the mechanism of labor and is willing to be guided by the action of the natural powers they are unnecessary, and in the hands of a man ignorant of the principles of obstetrics the instrument is too dangerous.

In cases in which great difficulty is experienced, an overlooked funnel pelvis will often be found, and the accoucheur will regret that he attempted delivery from below. Here again one should emphasize the necessity of careful antenatal examination and pre-partal decision as to the method of conduct in the approaching labor.

UNIV. OF MICH.

FROM THE CLINIC OF VILRAY PAPIN BLAIR

SWITCHING OF VERMILION-BORDERED LIP FLAPS

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FOLLOWING are some adaptations of the plan of the switching of vermilion-bordered lip flaps for improving balance after removal or loss from either lip. The blood supply through the coronary vessels makes it possible to turn such a flap on an extremely narrow pedicle. This is useful in patients with small lesions on the lip where, following a V-excision, there would be too much difference in the width of the lips if the defect were closed simply by suturing. With the flap available, there is not much tendency to cut too close to the growth, and because of the simplicity, of the technique, there cannot be much real argument against the excision of these growths, especially those that have had prolonged and many different kinds of treatment or unknown amounts of radiation. By this method, the whole specimen is obtained for microscopic diagnosis without much more trouble than in doing a biopsy (Figs. 1 and 2). Accumulated observation has led to the conclusion that all cases of suspected or clinically diagnosed malignancy should have the benefit of microscopic examination of the tissue, even if radium or any other destructive agent is to be used. If large sections of the lower lip are removed, an upper lip flap may be used in combination with other flaps (Figs. 2 and 3). The flaps may be advantageously utilized on patients with defects following former operations for growths, injuries, or disease; and in some re-operations for cleft lip (Fig. 4).

If the defect is near the angle on the lower lip, a triangle can be swung directly down from the upper, preserving the coronary vessels in a mucous flap. In this instance, the pedicle of the flap will form the new angle of the mouth (Figs. 1, 2, 3). The upper lip defect is closed by pulling the lip over to the cheek with any further adjustments necessary to lessen the distortion about the nose and upper part of the lip. The corner of the mouth is put in the best obtainable position, but this may be improved if necessary by some subsequent operation (Figs. 1C, 3B and C). The suturing should insure contact for the full depth of the wound (Figs. 1 and 2).

If the defect is near the middle of the lower lip, the remaining lateral portion may be raised as a somewhat rectangular flap and swung across to fill in the center. The defect at the side of the lip can then be filled in with a flap from the upper (Fig. 2).

For the swinging of a flap from the lower lip into the upper lip at or near the center, the pedicle must of course go across from one lip to the other and remain there until the flap has established its new blood supply. The pedicle is cut

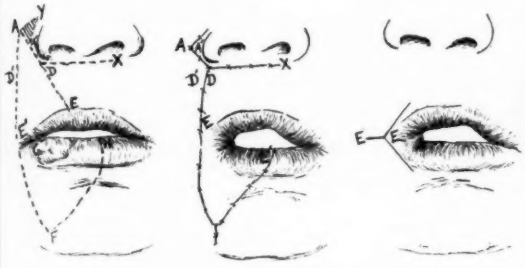


Fig. 1. Plan 1—Large removal from lower lip repaired by large triangular flap from upper lip that permitted immediate adjustment of the remaining part of upper lip to give the corner of the mouth the proper vertical level and not distort the nostril. A, Shows plan of cuts and excision. *E'H*, excised portion of lower lip; *E'EA*, triangular flap raised for filling in lower lip defect; *DX*, relaxation cut through full thickness of lip. *A'AV*, adjustment cuts, and this triangle discarded. B, Immediate adjustment. *DE* is moved over to the right aided by relaxation along *DX*. The line *AD'* in A has been pulled in so that its midportion occupies a place about where *D* was before the transfer; *E'* that was at the angle in the upper lip has been swung down around into position near the middle of the lower lip. *E* forms the new angle of the mouth. Stay sutures through the full thickness of the lip and cheek may be put in across line *DE* to relieve tension on the blood supply. C, Plans of Y cuts for V-adjustment to shift new corner outward. This step is done at a later time to allow freer opening. Y-incision made and *E* is dropped back to *E''* and the incision closed in a V. D, Condition for which Plan 1 is used. E, Final result.

D. E.

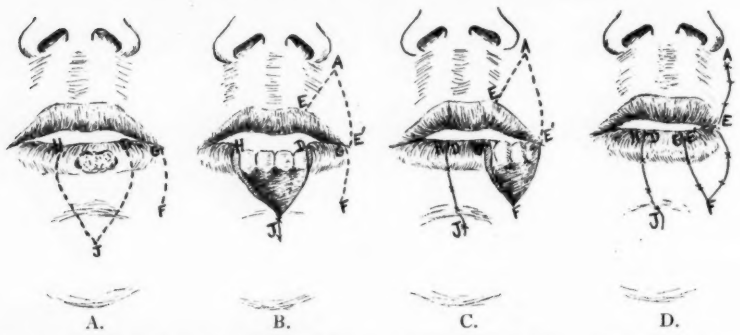


Fig. 2. Plan 2—Central defect of lower lip closed by a lateral flap from the same lip and the resultant lateral defect by a triangle from the upper lip. A, Shows *HDJ*, excision. *DJFG*, rectangular flap raised to fill in central defect. B, Shows *EAE'*, triangular flap raised to be transferred into defect in lower lip when *DJFG* is transferred to center. C, Shows the lateral flap transferred to the center. D, Shows the completed operation with the triangular transfer from the upper lip in place in the lower. The defect in the upper lip is closed by sutures without further adjustment and the result is final. The transfer of this triangular flap is the simplest of the procedures, and it can be used, usually without further adjustments, when there are only small lower lip defects at the corner to be filled in. E, Shows condition for which Plan 3 is used. F, Final result.

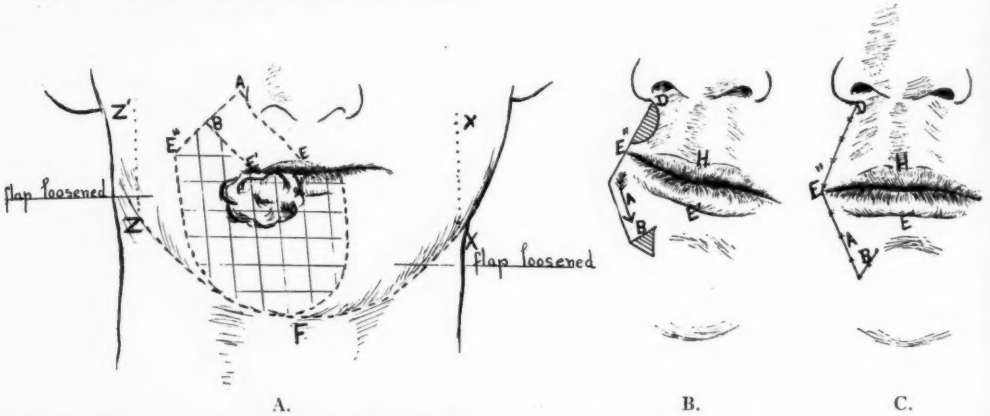
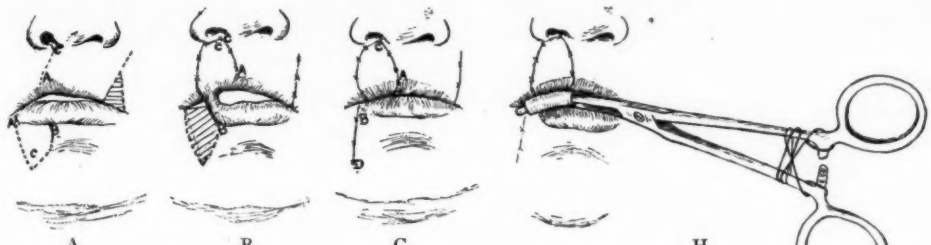
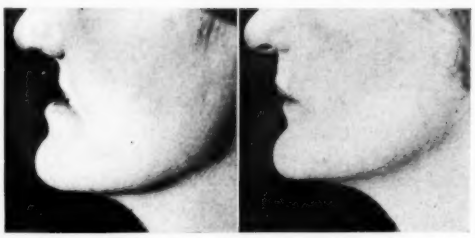


Fig. 3. Plan 3—Wide excision from lower lip, chin, and cheek; small excision from upper lip. Defect closed by cheek and chin flaps supplemented by a rectangular flap from the upper lip. A, The cross-checked area indicates the area excised. *EE'BA*, flap to be switched into defect. *XFZ* is a relaxation cut just superficial to the body of the jaw extending into the mouth; the buccal mucous membrane being also cut upward just in front of the ramus, *ZZ'* and *XX'*. The borders of the lower part of the defect are drawn together after swinging the flap *EE'AB* on the pedicle at *E*, and the upper lip is closed by approximating *AE''* and *AE*. B, Shows result obtained by first operation, which was further corrected as shown in B and C. The excision between *D* and *E''* lengthened the upper lip. The triangle excised at *B* gave space for lowering flap. Then the corner of the mouth with the flap was rotated downward on an axis *E''H*, with *H* as a center of rotation along the cut *DE''B*. C, Shows final result with fairly straight mouth. D and E, Show patient on whom excision and restoration was made according to Plan 3.





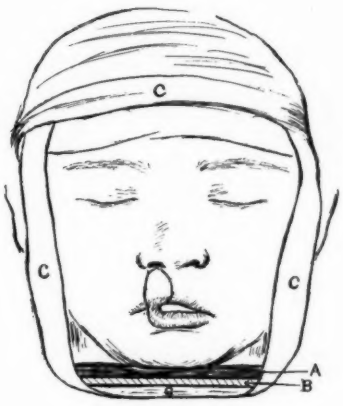


Fig. 4. Plan 4—Used for filling in defects of the upper lip at or close to the center. A, *A'C'* Line of opening lip to receive flap. *ABC*, flap raised in lower lip. The shaded triangle at the left corner of the upper lip is removed and the defect resutured to correct the deformity shown in D. B, Flap *ABC* in place in upper lip with the pedicle still attached to the lower lip at *B*, through which the blood supply goes. This pedicle is cut in from 2 to 3 weeks, after the vitality of the flap is tested by clamping the blood supply through the pedicle. Further adjustment of the vermilion of both lips is necessary but may be delayed for some time after the pedicle is cut if advisable. The defect in the lower lip is left open in this drawing to show the course of the pedicle. C, Pedicle of flap has been cut and the vermilion of both lips adjusted. *BD*, Line of closure in lower lip. D and E, Shows a condition for which Plan 4, is used. F and G, Same as Figure C and D. H, Shows method of gently compressing the pedicle to shut off the vessels through it to the flap. This is to determine the adequacy of the blood supply from the new bed of the flap, and it is started about the tenth day. A rubber covered clamp is used, and a rubber band is looped over the handles to obtain even elastic pressure. The catches on the clamp are used to hold the rubber band. I, Shows method of holding the mouth shut. The head is padded and a plaster cap is put on that holds the plaster sling from the chin. This has been found to be the most comfortable arrangement, although a silkworm gut stitch from one lip to the other, that does not interfere with the blood supply, has been used satisfactorily.

usually between 2 and 3 weeks and before cutting it, the new blood supply is tested by compressing the pedicle with a rubber-covered clamp for an hour or two (Fig. 4, H). If, after several hours of compression, repeated on several consecutive days, the color of the flap, while the pedicle is compressed, remains doubtful, it may be well to divide the coronary artery in the flap; but postpone the cutting of the rest of the flap until the new circulation is satisfactory. A flap switched into a scar bed may be slow in gathering its new blood supply. This compression should be gentle to avoid cumulative trauma. A plaster cap with a padded plaster sling down around the chin is the plan used for holding the mouth closed to prevent damage to the pedicle (Fig. 4, I).

The area to be excised or to be filled in and the flaps used for repair are to be carefully planned. Accuracy in this point will be evidenced in the result. The blood supply of the flap must be kept

in mind while the flap, is being cut as the pedicle consists of but little more than the vermilion border and the coronary vessels. The artery can be felt just under the mucous membrane.

There is seldom much trouble with function, although there may occasionally be some leakage of fluids because of lack of sensation or of muscular action. With a little training this can usually be overcome. The patient should put his spoon or cup against the lower lip at the repaired angle and take the food in from there. This same method proves of value to those patients who have lost the inframandibular branch of the seventh nerve from other causes. Most of the patients operated on have satisfactory control of the mouth, and none of them has any leakage of saliva. More accurate data is being collected on the nerve regeneration and muscular action.

In general, this plan tends rather satisfactorily to preserve some of the natural prominence and contour of the damaged lip and to prevent the excessive protrusion of its fellow that results from the obliteration of the original defect by the simple approximation of the borders.

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BRONCHOSCOPIC TREATMENT OF PULMONARY ABSCESS[1]

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PULMONARY abscess offers one of the most difficult problems in diagnosis and treatment. It has been estimated that approximately 50 per cent of the cases of untreated pulmonary abscess terminate fatally. Miller and Lambert[2] found that the mortality rates in surgery for pulmonary abscess varied between 10 and 60 per cent, depending on the operator and number of thoracic operations he had performed.

It is fortunate that bronschoscopy has been of so much value in treating pulmonary abscess, and has produced such splendid results. Although applied successfully only in recent years, it has already surpassed our greatest expectations and now stands as the most valuable aid in the treatment of this condition.

DIAGNOSIS

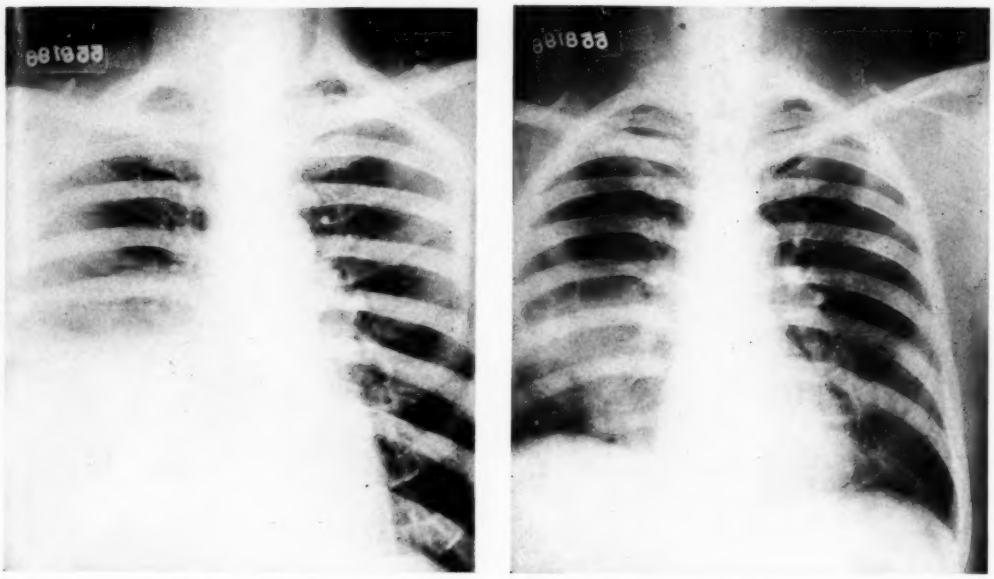
Before the bronchoscopic treatment of pulmonary abscess and the results obtained are discussed, it is necessary to define what is meant by pulmonary abscess. Unfortunately, the term is mistakenly applied to many pulmonary conditions. It is easy to understand why these mistakes occur since even the pathologist with the specimen in his hands can not always distinguish accurately between a bronchiectatic condition and pulmonary abscess. A further complication is introduced by the fact that the older an abscess grows, the more closely its structure resembles that of bronchiectasis; also walled-off empyema may simulate pulmonary abscess and may easily be mistaken for it.

The necessity of distinguishing between pulmonary abscess and other forms of pulmonary suppuration, as far as possible, is obvious because of the marked difference in their response to medical and surgical treatment. The possibility of relieving pulmonary abscess is far greater than that of relieving other types of pulmonary suppuration, especially bronchiectasis. An abscess involves chiefly the parenchyma of the lung—tissues which are elastic and pliable and able to regenerate. After the cavity is drained, its walls tend to collapse, and healing takes place. Bronchiectasis chiefly involves the bronchi, which are rigid tubes and do not collapse when pus is removed but expand in response to extrinsic and intrinsic forces. In time, a pulmonary abscess becomes walled off by means of fibrous tissue which forms a rigid wall resembling the structure found in bronchiectasis; it is for this reason that pulmonary abscess of long standing is less amenable to treatment.

Clinically, the diagnosis of pulmonary abscess is based on the history, which is of the greatest importance, on the physical findings, on the roentgenogram, and, finally, on bronchoscopic examination. While errors in diagnosis are relatively easily made in a condition such as pulmonary abscess, especially in its differentiation from bronchiectasis, still the cases in the group under consideration in this paper have been

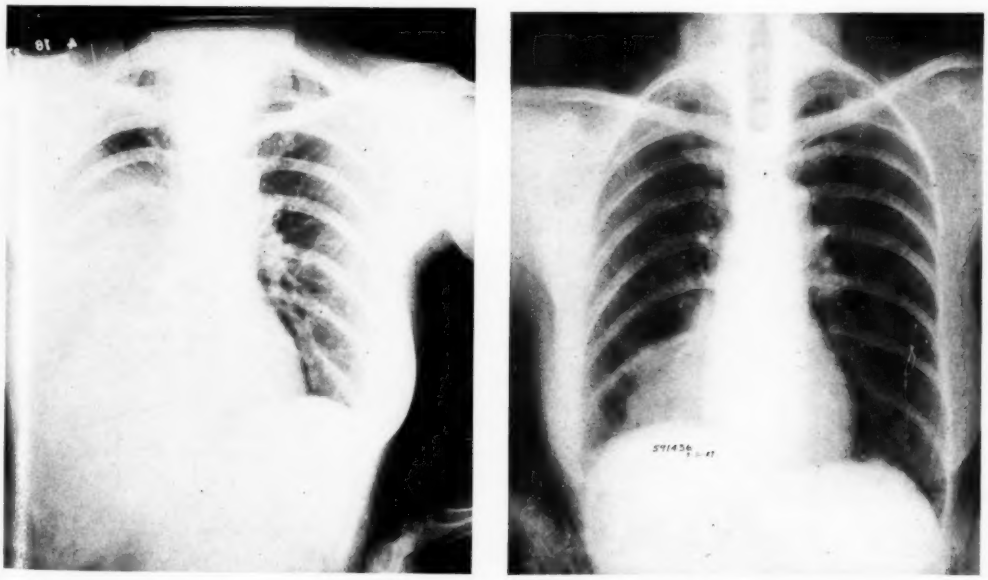
[2] Treatment of abscess of lung. Am. J. M. Sc., 1926, clxxi, 81.

[1] Submitted for publication November 18, 1927.



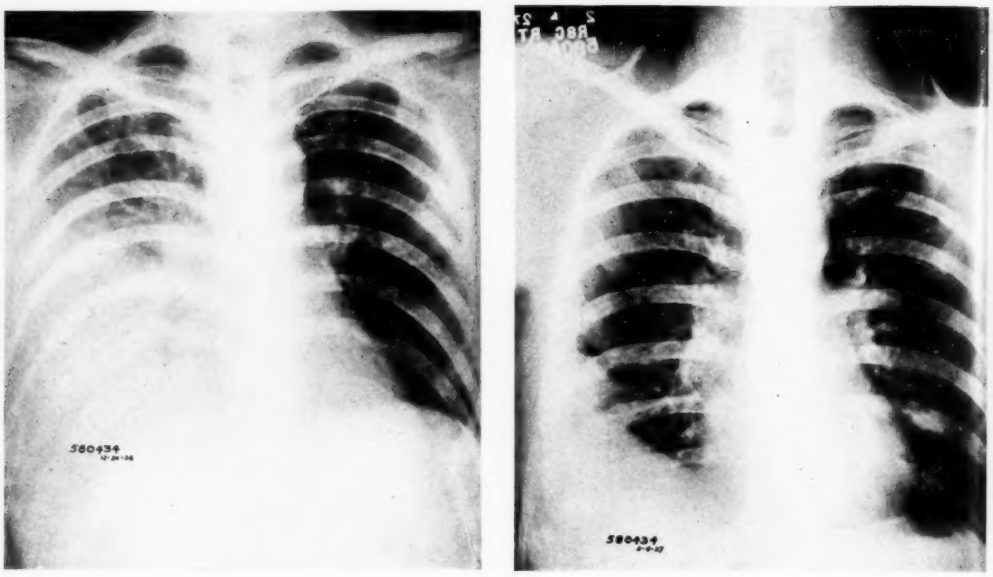
A. B.

Fig. 1. A, Pulmonary abscess of 3 months' duration (postpneumonic). B, After 4 bronchoscopic aspirations. Clinical symptoms disappeared; patient gained 36 pounds and returned to work 4 months after onset of symptoms.



A. B.

Fig. 2. A, Abscess of lung. B, After 2 bronchoscopic treatments within 5 weeks.



A. B.

Fig. 3. A, Postoperative pulmonary abscess of 20 days' duration. B, Two months after one bronchoscopic aspiration.

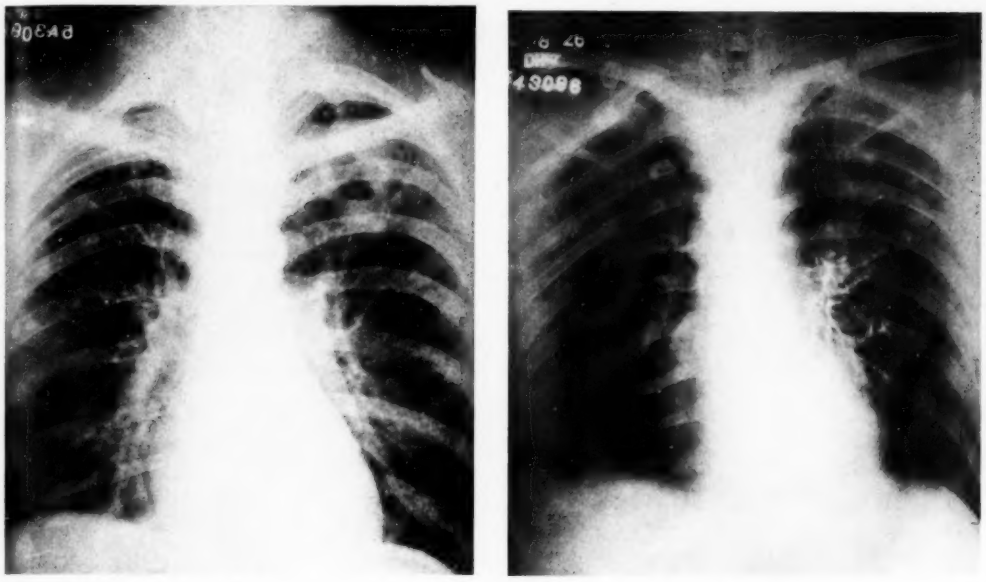
as definitely diagnosed pulmonary abscess as is possible by present diagnostic means.

TREATMENT

It is extremely important that the bronchoscopist and the thoracic surgeon work in close harmony in cases of pulmonary abscess since complicating factors, such as empyema, may necessitate operation. The bronchoscopist, on the other hand, can often give the surgeon valuable information when operation is indicated. It is only through the correlation of bronchoscopy and surgery that the best results can be obtained.

The essential factor in the bronchoscopic treatment of pulmonary abscess, as in suppuration elsewhere in the body, is sufficient and proper drainage. For some reason most bronchoscopists regard the lung as a friable and delicate organ which must be handled with the greatest care. When pus is to be aspirated or an abscess drained, the aspirator is introduced through the opening in the abscess very gently, and nothing is disturbed. If one considers the trauma to the lung in pulmonary operations or the ease with which the lung stands injury when foreign bodies are inhaled, such precautions seem unnecessary in treating pulmonary abscess. First of all, it is essential that the area of the abscess be definitely located and this is usually possible from the appearance of pus in the bronchus draining the area involved. At times the site of the abscess is manifested by bulging or obstruction of the lumen of a bronchus due to inflammatory swelling. When the affected area is definitely located, an aspirator is introduced into the bronchus from which the pus is exuding or which is obstructed by œdema and inflammation. If pus is obtained the aspirator is moved in every possible direction to insure the removal of pus from every accessible pocket. Abscesses may be divided into multiple small pockets and, if the aspirator is moved about, many of the barriers will be broken down, thus insuring better drainage. If the opening into the abscessed area is so small or stenotic as to interfere with the free flow of pus, it should be forcibly dilated with a heavy pair of dilating forceps. If necrotic or fibrous tissue obstructs the opening, it should be removed with biting forceps. If the abscess is caused by a foreign body, the offending material as well as any calcareous deposits that may have formed must be completely removed if the best results are to be obtained.

When the abscess does not drain into a bronchus, but bulges into a bronchus, one should not hesitate to introduce an aspirator directly into the



A. B.

Fig. 4. A, Pulmonary abscess of left upper lobe of indeterminate origin. B, Two weeks later after one bronchoscopic aspiration. Iodized oil (40 per cent) injected previous to bronchoscopy can still be seen.

abscess. I have never noted any ill effect from such a procedure. It is not advisable to probe into the pulmonary tissue through the bronchial wall in the hope of encountering the abscess; however, if one can be absolutely certain of the site of the abscess, he is justified in burrowing through normal lung tissue to reach it. Some bronchoscopists have feared that fatal hæmorrhage might result from this procedure. However, I have found that, although bleeding may occur, it is not severe. Blood vessels are undoubtedly torn, but because of the size and shape of the instruments used they are more than likely torn completely across rather than partially torn. The ruptured end of a vessel torn completely across retracts and contracts more thoroughly; this is of prime importance in the control of hæmorrhage.

REVIEW OF CASES

During 1925 and 1926, 19 cases of diagnosed pulmonary abscess were treated bronchoscopically with the following results. In 16, excellent results were obtained from bronchoscopic drainage. In 1 case, the result was indeterminate and the patient is still under observation. In 1 case, operation was resorted to as the results from bronchoscopy were unsatisfactory. Death occurred in the case of a man whose symptoms had persisted for 1 year and were of indeterminate origin. He improved markedly after 2 bronchoscopic drainages and was permitted to return home. Four months later he died but I have been unable to obtain information as to the cause of death. In the absence of definite information, I have attributed his death to the pulmonary trouble. Therefore, in the group under consideration, satisfactory results were obtained in 84 per cent. It is my belief, however, that with increased knowledge and improved bronchoscopic technique, this percentage will be increased.

The causes of pulmonary abscess in the 19 cases under consideration were as follows: pneumonia in 4; inhaled foreign body in 3; aspiration at tonsillectomy in 2; aspiration at dental extraction in 2; aspiration during other operations in 3; influenza in 1; secondary to aspiration in cardiospasm in 1, and some indeterminate cause in 3. The etiological factor seems to play an indefinite rôle in determining the prognosis in all of these cases.

The length of time that the abscess has existed is important in the prognosis. The duration of the disease in this group varied from 20 days to 6

years. When the abscess had been present for 1 month or less, excellent results were obtained from bronchoscopic drainage; this was also true of cases in which the symptoms had been present less than 3 months. Although abscesses of longer duration as a rule responded less rapidly to treatment, this was not invariable, as the abscess which had been present 6 years was cured by 1 bronchoscopic treatment.

The number of bronchoscopic treatments necessary in these cases varies considerably. In 12 cases, only a single bronchoscopic treatment was required; in 2 cases, 4 were required. The number of treatments depends on the efficacy of drainage. There are many factors that must be considered before too definite conclusions are drawn concerning any particular procedure in the treatment of pulmonary abscess. Abscesses occasionally drain or rupture spontaneously with complete relief of symptoms, although this is rare in those of long standing. In my experience abscess of the right lung has been easier to treat than that of the left, chiefly because of mechanical factors. The age of the patient has little influence on response to treatment. In the present series the ages varied from 22 to 74 years.

The illustrations demonstrate as well as roentgenograms can the results obtained by the bronchoscopic treatment of pulmonary abscess. Because of pleural thickening it is difficult to obtain as accurate a conception of the improvement as from examination and clinical data.

CONCLUSION

1. Bronchoscopy is of paramount importance in the treatment of pulmonary abscess.
2. Remarkable results are obtained with little risk.
3. Time and expense consumed in treatment are reduced to the minimum.
4. Adequate and proper drainage is essential to success.

THE THERAPEUTIC VALUE OF LIPIODOL IN EMPYEMA

By J. LOUIS RANSOHOFF, M.D., F.A.C.S. and JOSEPH D. HEIMAN, M.D., Cincinnati, Ohio
From the Surgical Department, Jewish Hospital

DURING the past 3 years we have treated acute empyema by closed intercostal aspiration drainage, followed by 2 hourly instillations of Carrel-Dakin solution. These instillations are continued until all symptoms have subsided and the bacterial count of the secretion from the fistula is reduced to 2 or 3 bacteria per field. The tube is then removed and the wound allowed to close. Though this method has, in the main, yielded satisfactory results, there has been a small percentage of cases in which this treatment was inadequate. In a few instances, subsequent rib resection with open drainage has been necessary. This, in a measure, constitutes therapeutic failure, as it results in long hospitalization, deformity, and possibly chronic empyema.

In January, 1927, we began using injections of lipiodol, to determine the size of the residual cavity before removing the tube. It at once became evident that cases handled in this manner had an unusually uneventful recovery. In no case in which lipiodol was injected was it necessary to re-institute drainage or irrigations. The wounds were dressed and soon healed completely.

Case 1. P. E., female, aged 4 years, had metapneumonic empyema. The patient was admitted to the Jewish Hospital, March 24, 1927, with the diagnosis of left lobar pneumonia. On March 30, physical examination and X-ray revealed a large collection of fluid in the left pleural cavity. This was drained, on April 1, by the closed aspiration method. Bacteriological examination revealed pneumococcus, type 1. Instillations of Carrel-Dakin solution were instituted and continued until April 16, 1927, when the tube was removed. On April 19, the temperature reached 103 degrees. The leucocyte count was 15,200. On April 26, the tube was re-introduced and the irrigations of Carrel-Dakin solution re-instituted. However, the patient's temperature never came to a continuous normal nor was the cell count reduced to satisfactory limits. On May 20, lipiodol was injected through the tube and the tube clamped. X-ray examination showed a large cavity extending from the fourth to the tenth rib (Fig. 1). The tube was removed on May 28, and the wound dressed. The child was discharged June 7, completely recovered.

Case 2. P. G., male, aged 8 years, was admitted January 1, 1927, with a diagnosis of metapneumonic empyema. Aspiration drainage was done on January 2, followed by Carrel-Dakin instillations. A culture showed pneumococci. There was no improvement; the temperature remained elevated, reaching its peak at 105 degrees. On January 16, the leucocyte count was 16,500, and the culture from the wound showed staphylococci and streptococci. On January 17, under local anæsthesia, a resection of the eighth rib was done in the axillary line and open drainage instituted. This was followed by instillations of Carrel-Dakin solution. On January 30, lipiodol was injected and an X-ray picture taken. It showed a large interlobar triangular cavity with branches extending upward and downward (Fig. 2). Two days later a second injection of lipiodol was made. From that time on there was a gradual improvement. On February 18, lipiodol was again injected and the

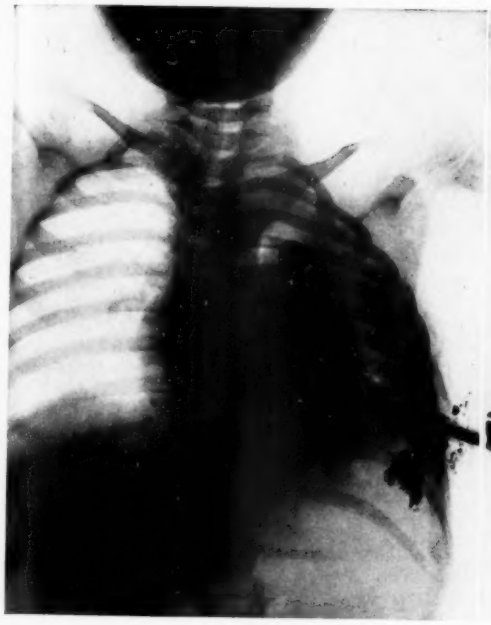


Fig. 1. Case 1.

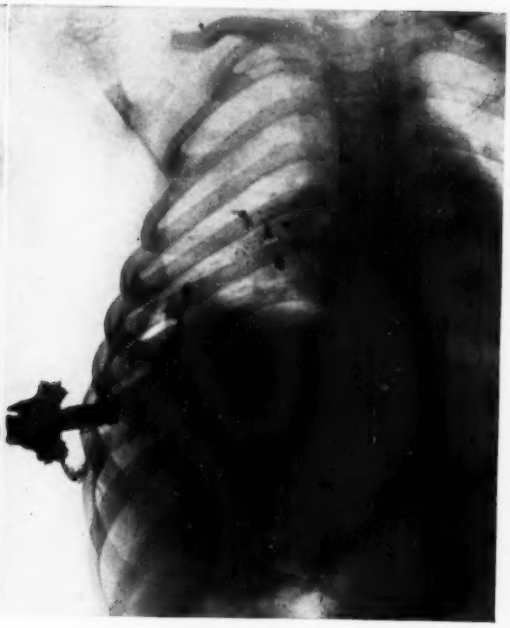


Fig. 2. Case 2.

Fig. 3. Case 3.

Fig. 4. Case 4.

Fig. 5. Case 5

tube clamped for 2 days, after which it was removed. On March 3, he was discharged with the wound healed, temperature having been normal for over 2 weeks.

CASE 3. J. E., male, aged 16 years, was admitted on May 31, 1927. He had been ill for 3 weeks with left lobar pneumonia. June 1, the leucocyte count was 23,000. On June 2, aspiration drainage was made, followed by instillations of Carrel-Dakin solution. Smear showed gram-negative cocci. On June 27, lipiodol was injected, the tube clamped, and a picture taken showing a large cavity extending from the sixth rib to the diaphragm (Fig. 3). The tube was removed on June 29. There was no further rise in temperature, and patient was discharged July 10.

CASE 4. M. F., female, aged 55 years, was admitted to the Jewish Hospital, May 14, 1927. This patient had been ill for several weeks with symptoms of gall-bladder disease. There was a low grade of fever. Leucocyte count varied between 12,000 and 16,000. X-ray examination of the chest revealed a right pleural effusion. After ingestion of tetra-iodophenolphthalein the gall gladder failed to fill. Stomach, duodenum, and large intestine were normal. Occult blood was found in the stool. On May 17, about 1,000 cubic centimeters of dark amber-colored fluid, slightly tinged with blood were removed, by aspiration from the chest. Gram-negative bacilli were found in the fluid. It was thought probable that this effusion was secondary to a probable metastatic carcinoma of the lung. On May 22, 600 cubic centimeters of fluid of the same character were removed by aspiration. During all this time, the patient had marked gastro-intestinal symptoms, pain in the abdomen, and frequent vomiting. On June 4, aspiration revealed thick, creamy pus, containing gram-negative bacilli. On June 6, aspiration drainage was done in the eighth interspace, in the posterior axillary line. This was followed by instillations of Carrel-Dakin solution, which were continued until June 27, when lipiodol injection was made and an X-ray picture taken, which showed a large irregular cavity located posteriorly, extending from the fourth to the tenth rib (Fig. 4). The tube was clamped off, removed after 2 days, and the wound allowed to close. Convalescence was uninterrupted. The patient was discharged on July 14.

CASE 5. L. C., female, aged 23 years, was admitted to the Jewish Hospital, December 19, 1926. Diagnosis: chronic empyema of the right side. This had been present for 4 years, originally following an attack of pneumonia. She had had 4 operations in an endeavor to close the fistula. The patient was well developed and nourished, and aside from the fistula in the anterior axillary line of the sixth rib, there was nothing noteworthy in her physical examination. Injection of saline solution showed that the cavity held about 3 ounces. Tubes were inserted into the cavity in an endeavor to sterilize it with Carrel-Dakin solution. An operation was performed on December 27. The fistula and surrounding skin area were removed and a wide resection of the sixth rib was made. Wide areas of the fourth and fifth ribs were then resected. The tract was then probed with a catheter and found to extend upward and forward for a distance of 7 or 8 inches behind the sternum. As it was impossible without resection of the sternum to lay this cavity wide open, it was enlarged to the greatest possible diameter by stripping the anterior surface of the lung from the anterior chest wall. The entire wound was packed with iodoform gauze. On December 30, the packing was removed and Carrel-Dakin instillations were begun. These were continued until February 8, when lipiodol was instilled and an X-ray picture taken, which showed a long fistulous opening, extending upward and forward, communicating with a cavity located between the second and fourth ribs anteriorly, and about 1 inch from the anterior chest wall (Fig. 5). The instillation of lipiodol was repeated on the second and third day. The wound was dressed without subsequent irrigations and the patient discharged 4 days later, with instructions to dress her wound daily. Three weeks later the wound was completely healed.

When it is determined that the bacterial count is reduced to satisfactory limits, a sufficient amount of lipiodol is instilled through the catheter to fill the cavity. An X-ray picture is taken, the catheter clamped so as to retain as much as possible of the lipiodol in the cavity. As was shown in Case 2, the lipiodol instillations may be repeated with advantage. After 2 days the tube is removed and a simple dressing placed on the wound. No subsequent irrigations should be made. These results are interesting in the face of Archibald's article[1] in which he disclaims any therapeutic or bacteriological properties of lipiodol.

CONCLUSIONS

In the 5 cases which have been reported, 4 were acute and 1 chronic. All healed rapidly after injection of lipiodol. The chronic case is of particular interest, since it was especially obstinate and a large cavity extended upward under the sternum and could not be satisfactorily exposed.

The injection of lipiodol into the residual cavity after treatment of empyema by aspiration drainage and Carrel-Dakin instillations seems to have a decided beneficial action. It is simple, free from danger, and should be given a trial.

[1] J. Am. M. Ass., 1927, April 23.

ANGIOMA OF THE KIDNEY[1]

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ANGIOMA is the rarest of benign tumors of the kidney. Some observers have even doubted its existence and have ascribed the localized areas of extreme vascularity which occur in the kidney to congenital malformation, localized ectasia, or trauma of the renal parenchyma. Cases have been reported, however, in which it is difficult to explain the observations on any basis other than that of true tumor formation. Whether these lesions are congenital or acquired remains problematic.

LITERATURE

The literature pertaining to renal angioma is limited almost entirely to case reports; we have been able to collect 11 which seem to be authentic (Table 1).

Virchow mentioned angioma of the kidney and believed that it occurred rather commonly, only less so than angioma of the liver. He reported angiomata of the kidney in conjunction with similar tumors in the liver.

Lutz reported the case of a man, aged 62 years, who for 5 weeks had suffered from hæmaturia originating in the right kidney. The kidney contained a tumor a little larger than a cherry stone, situated at the intersection of the medulla and the pelvis. It was a spongy growth with great endothelium-lined spaces, some of them filled with blood. Lutz also referred to several cases which had been reported in the literature.

Stieda reported the case of a man, aged 29 years. Hæmaturia originating in the right kidney had been present for 6½ years. Decapsulation was without effect and later the kidney was removed. It contained an area in the tip of a papilla composed of typical angiomatous tissue.

Swan reported a case from personal observation and referred to several cases in the literature.

REPORT OF A CASE

The patient was a woman aged 57 years. For 20 years there had been attacks of hæmaturia occurring every 4 or 5 years and lasting from 2 to 3 weeks. They were sometimes associated with left-sided renal colic. The bleeding was at times so severe that the patient became weak and lost weight, but she always recovered rapidly after the bleeding ceased.

On examination she appeared healthy. Neither kidney was palpable. Cystoscopic examination demonstrated that there was less excretion from the left kidney than from the right. The left pyelogram was normal.

In view of the history of repeated renal hæmorrhage, often of alarming degree, associated with pain, which was always referred to the left side, and of the reduced function of the left kidney, it was thought advisable to explore the left kidney. At operation the superior pole was found to be occupied by many dilated blood vessels, and nephrectomy was performed. Convalescence was uneventful and 3 months later the patient was perfectly well.

The kidney was small. The capsule was stripped off easily and the surface of the kidney was granular. The tumor was situated in the cortex and occupied the upper pole. It measured 1.5 by 2.5 centimeters, and its outlines

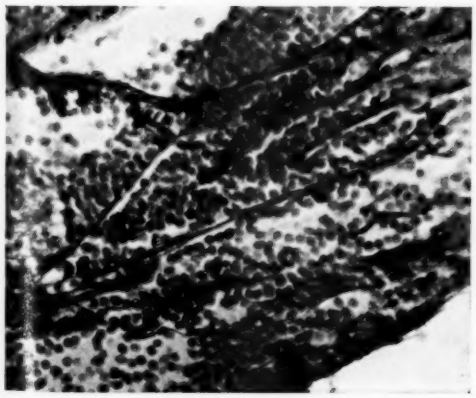

Fig. 1. Angioma of the kidney. The endothelium-lined spaces filled with blood are shown. (×200)

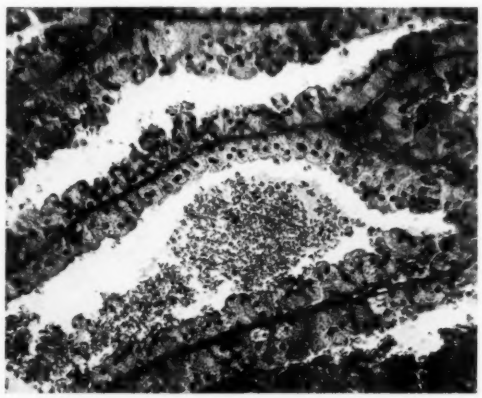

Fig. 2. Tiny carcinoma of the kidney. The blood-filled spaces are lined with epithelium. (×150)

[1]Submitted for publication October 29, 1927.

TABLE I.—SUMMARY OF CASES OF RENAL ANGIOMA REPORTED IN THE LITERATURE

	Age (years) sex	Side	Gross description	Microscopic appearance	Clinical symptoms	Remarks
1. Deanesly, quoted by Swan	66 M	Left	Numerous tumors, cortical	Capillary angioma	Intermittent hæmorrhage, 5 months	History of injury
2. Fenwick, quoted by Lutz	18 F	Left	Cluster of vessels, papillary tip		Hæmaturia 5 years	
3. Fenwick, quoted by Lutz	30		Varicose vessels, papillary tip	Blood filled vessels	Severe bleeding, 14 days	
4. Lutz	62 M	Right	At juncture of pelvis and medulla, 7 mm. diameter	Endothelium - lined spaces; hyalinized glomeruli	Hæmaturia 5 weeks; general health good	Nephrectomy with recovery
5. Rovsirg, quoted by Lutz			In papilla, 7 mm. diameter		Hæmaturia	
6. Rolleston and Kanthack	62 M	Left	In cortex, size of walnut	Remains of parenchyma in walls, encapsulated	None	Marked arteriosclerotic change in kidney; patient had epithelioma of larynx
7. Morris	23 F	Left	Multiple tumors in medulla	Vascular spaces with and without muscle in walls	Intermittent hæmaturia and pyuria several years	Slight chronic interstitial nephritis
8. Sennels, quoted by Wheeler					Hæmaturia	
9. Stieda	29 M	Right	Small tumor in papilla	Cavernous angioma	Hæmaturia 6½ years; recently severe; hæmoglobin 28%	Ulceration into pelvis
10. Swan	19 M	Left	Oval tumor in renal substance	Angioma with dilated capillaries	Profuse hæmorrhage, 3 days	Emergency operation with recovery
11. Virchow, quoted by Wheeler			Multiple, subcapsular and pelvic tumors	Angioma		

were irregular, although it was sharply demarcated from the surrounding parenchyma.

Microscopically the glomeruli were moderately sclerotic, especially in the region of the tumor where there was also moderate round-cell infiltration. The tumor was sharply demarcated from the renal tissue but there was no evidence of encapsulation. It was composed of a network of capillaries and endothelium-lined spaces, filled with blood (Fig. 1). The blood cells were for the most part well preserved but, in some areas, they had disintegrated and considerable blood pigment was deposited throughout the tumor.

SYMPTOMS AND TREATMENT

Angioma may give rise to clinical symptoms; there is practically always hæmaturia, which usually occurs as a result of ulceration into the renal pelvis. The bleeding may be severe, producing marked anæmia, and, at times, it may be so severe and prolonged that the patient goes into a state of shock. When the angioma is in the cortex it frequently produces no symptoms.

In the cases reported, the only definite symptom before operation was bleeding, without any obvious cause, from one kidney. The side from which the blood escaped could be determined by cystoscopic examination. In several instances the diagnosis of essential hæmaturia has been made, but when the bleeding continued, and obviously was from only one kidney, nephrectomy was performed and the angioma found. Because of the peculiar lack of clinical evidence on which to base a definite diagnosis in these cases and because of the inaccessibility of these tumors at exploration except when they are situated in the cortex, it frequently happens that the diagnosis cannot be made even with the kidney in view. In these cases nephrectomy has been performed because of severe or prolonged unilateral renal hæmorrhage.

GENERAL DISCUSSION

It is generally conceded that angiomata probably never attain a diameter greater than 1 or 2 centimeters. In most instances they have been solitary, but in the case reported by Morris they were multiple and situated in the medullary portion of the kidney, while in the cases cited by Deanesly and Virchow they were multiple and situated in the cortex.

Unlike the other types of benign renal tumor which have a predilection for the cortical zone, angiomata occur either in the cortex or in the medulla, often in the papillæ. They may or may not be encapsulated. In Morris' case the tumors were definitely encapsulated. The age of the patients in the cases described in the literature has varied from 18 to 66 years; the average was 38

years. In 7 cases the sex was mentioned; 5 were males and 2 females. In 5 of 7 cases in which the situation was mentioned the tumor was in the left kidney, and in 2 in the right.

In the cases described in the literature the microscopic structure has consisted of either large cavernous sinuses lined with endothelium, or thick-walled vessels, more or less dilated and filled with blood. Thrombosis has been observed within these vascular channels, and, in several instances, deposits of calcium salts. Surrounding the vascular channels there may be round-cell infiltration and deposits of pigment.

A distinction must be made between true angioma and other blood-containing tumors which may occur in the kidney. Carcinoma, in which the spaces and cavities have become packed with blood cells (Fig. 2) is most likely to lead to confusion. Such a tumor may be distinguished by the type of epithelium lining the blood-filled spaces, and a close examination of different portions of the tumor will usually disclose areas in which hæmorrhage has not occurred. Hæmorrhagic cysts of the kidney will not be confused with angiomata if one remembers that angiomata are practically always small, while hæmorrhagic cysts are usually quite large. As shown in a previous paper, these cysts usually represent an occluded aneurism and consist of a single cavity, while angiomata are composed of multiple cavities. Begg reported a case in which he found angiomatous tissue in the periphery of a hæmorrhagic cyst, which he believed was responsible for formation of the cyst. Trauma may result in the escape of blood within the interstitial spaces of the kidney but obviously here again the microscopic picture serves to distinguish this extravasation from angioma.

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PYLORO–DUODENOSTOMY FOR DUODENAL ULCER[1]

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IN presenting a new operation for peptic ulcer of the stomach or duodenum, one must keep in mind that all lesions in these areas, which require surgical therapy, depend more upon the operation of gastrojejunostomy than upon any other operative procedure, and that without this operation, surgery of the stomach would never have occupied the useful position that it does today. In those instances wherein the anastomosis does not function properly, it can be undone; a situation which can never arise with more radical forms of unsuccessful gastric surgery. When there is a more or less complete and permanent obstruction in the stomach or duodenum, gastrojejunostomy, thereafter, drains all of the gastric contents. When an ulcer is present without complete obstruction, the greater portion of the gastric contents, soon after the operation, passes back through normal channels, viz., the pylorus and duodenum. Under these conditions, the spastic obstruction in the ulcerated area is relieved and held inactive by the anastomosis which prevents an accumulation in the stomach of gastric secretions sufficient to produce an irritation with its resultant spasm in the ulcer area.

For the successful functioning of this operation, the essentials are a proper indication and a proper technique which will bring about a complete drainage of the proximal loop and sufficient drainage of the stomach. The greatest barriers are reflex disturbances of the gastric segment and incomplete drainage of the proximal loop and stomach contents. When a gastrojejunostomy is properly performed upon a patient troubled with a stomach syndrome resembling that of a gastric or duodenal ulcer but due to a gastric reflex, the anastomosis merely adds to the distress of the patient. However, it is not the peptic ulcer, with or without organic obstruction, which makes this operation successful. Its success depends, in the presence of a proper technique, upon an absence of reflex gastric spasms and a postoperative anatomical position of the anastomosis wherein the jejunal loops are completely, and the stomach sufficiently, drained. Gastrojejunostomies should produce no more distress in persons with perfectly normal stomachs and duodenums than in those with peptic ulcers, with or without organic obstructions. It seems rational, therefore, to assume that the primary pathological condition has nothing to do with the functioning of this operation, because it functions as well remotely after the operation when the stomach or duodenum has been restored to normal or as near normal as possible.

There is a small percentage of patients in whom the most popular gastrojejunostomy, in the hands of many surgeons, will not function without distress, perhaps because of an unavoidable postoperative position of the anastomosis which interferes with proximal loop drainage. Balfour and Moynihan well state that with the enormous number of gastrojejunostomies performed there are bound to be a small number unsuccessful, which gives undue publicity to this, one of the most useful of all surgical procedures. It is an operation which has destroyed or removed nothing; having merely added a new function which cannot, as with all forms of therapy, be expected to be successful to a degree approximating a percentage of 100.

The number of patients in whom a gastrojejunostomy will not function satisfactorily, because of insufficient drainage of the stomach and jejunal loops, is large enough, however, to demand attention. There are few operations which leave the average surgeon with more anxiety relative to immediate and remote postoperative obstruction, owing to the fact that the postoperative positions and condition of the anastomosis and the amount of obstructive peritoneal adhesions surrounding it can not always be foreseen. This inability to obtain perfectly successful gastrojejunostomies in all patients, together with the occasional secondary gastrojejunal ulcer, has led to the adoption of numerous modifications and new surgical procedures.

The operation I am describing here is brought forth with the idea that it is not a substitute, in the majority of instances, for the properly indicated and properly performed gastrojejunostomy for duodenal ulcer. I feel that it has a place following an undoing of an unsuccessful gastrojejunostomy, and also in some instances wherein it may function satisfactorily without the help of a gastrojejunostomy. Another qualification is that it simulates the normal more than any other operation as yet proposed, and if it is unsuccessful, it can be helped by the addition of a gastrojejunostomy.

[1]Read before the Mayo Clinic at a meeting of the Permanent and Ex-Resident Staffs, September 27, 1927, Rochester, Minnesota.

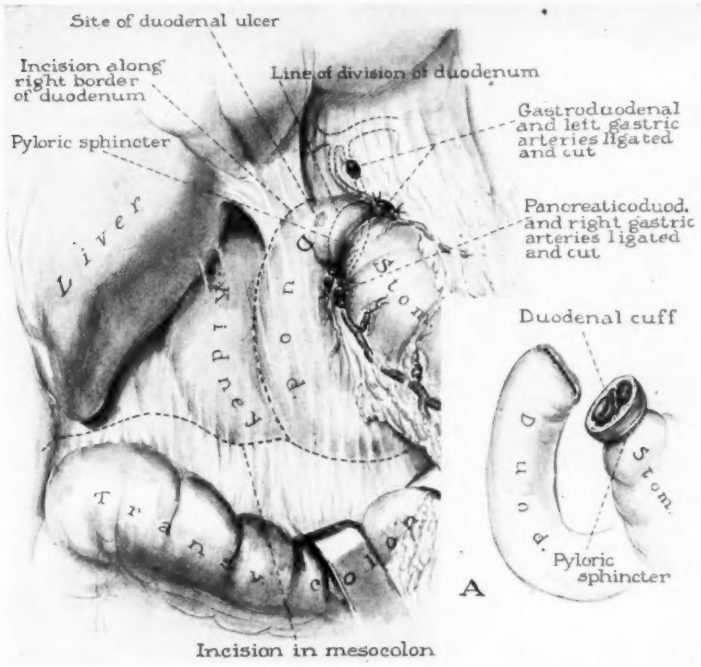

Fig. 1.

TECHNIQUE

Six years ago, shortly before Haberer[1] described his anastomosis of the resected stomach to the duodenum, I began performing the operation herein described. The essential difference between Haberer's operation and mine is that he applies his operation after resection of the distal end of the stomach for gastric ulcers. I apply my operation for ulcers of the duodenum, leaving the distal end of the stomach, including the pyloric sphincter, intact. Haberer's operation is an implantation of the amputated stump of the stomach into the second portion of the duodenum, while my operation is a re-implantation of the pyloric sphincter into the second portion of the duodenum.

The contra-indications to an attempt to perform this operation are too firm congenital and inflammatory fixations of the descending portion of the duodenum and multiple duodenal ulcers which might prevent a permanent closure of the duodenal stump.

The ideal conditions indicating the performance of this operation are a lack of obesity, a more or less naturally mobile duodenum, and a single small duodenal ulcer. The ability of the surgeon as an operator will modify these statements to a certain degree.

Ample mobilization of the duodenum is essential, and can be brought about in proper instances by cutting the mesentery of the hepatic flexure and adjacent transverse colon free from the posterior abdominal wall, right kidney, and duodenum. This incision is added to Kocher's which is an incision through the peritoneal reflection of the outer border of the descending duodenum. With this combined method and a careful finger dissection, the descending and transverse duodenum up to the superior mesenteric vessels can be mobilized to a surprising degree. Care must be exercised not to destroy the blood supply which comes to the duodenum on its concave surface.

After sufficient mobilization is accomplished, the duodenum is amputated through its second centimeter from the pyloric ring and the distal opening carefully closed. The ulcer is inverted as the walls of the duodenum are sewed in and, without doubt, is destroyed by the resultant healing process brought about by the inverting sutures.

[1] Zentralbl. f Chir., 1922, v, 49, No. 36, 1321.

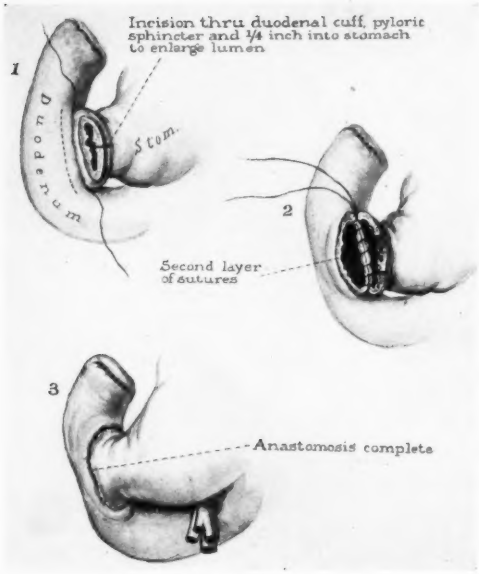

Fig. 2.

The pylorus, with its narrow duodenal cuff, is then ready for its anastomosis with the second portion of the duodenum on its peritoneal surface. Experience has taught me that a transverse incision through the pyloric sphincter prevents a too narrow anastomotic lumen, as well as a spastic obstruction. This incision should be carried through the duodenal cuff, pyloric sphincter, and about 1 or 2 centimeters of the stomach wall.

Most painstaking, small but deep-biting sutures on a sharply curved needle are necessary for the outer row of the anastomosis in order to prevent too much infolding and consequent narrowing of the inner orifice. Traction on the anastomosis may be prevented by attaching the falciform ligament of the liver well up on the first half of the stomach, after the method which is used by W. J. Mayo.

RESULTS

I have 5 patients now in excellent health, and their operations were performed 6, 4, 2, 1, and ½ years ago. I have not restudied any of these recoveries with the roentgen-ray and gastric analyses, because of the difficulty of having the patients return for examination; but letters from them state that they are perfectly well. This small series of patients indicates that this operation has possibilities.

GASTRO-ŒSOPHAGEAL CARCINOMA: ITS DIAGNOSIS

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MALIGNANT lesions of the cardia and of the stomach fundus frequently offer great difficulties in diagnosis. This is particularly true of early cases, that is, before the onset of marked loss of weight, anæmia, and cachexia. Unfortunately, this triad of symptoms is considered by many physicians absolutely essential for the positive diagnosis of malignancy; a view in a large measure fostered by the unnecessary prominence given these signs in textbooks. Malignancy of the cardia and of the lower œsophagus is so relatively benign and metastases occur so late that successful surgical treatment may be possible provided diagnosis is made sufficiently early.

It is the purpose of this paper to report a survey of the methods used by various clinicians and roentgenologists in establishing early diagnosis; to attempt to estimate the relative value of clinical symptoms (objective and subjective) generally considered of cardinal importance; and to report two cases which gave rise to considerable difficulty in diagnosis.

RELATIVE INCIDENCE

In an attempt to determine the relative incidence of carcinoma of the cardia, it was found that it is included indiscriminately in the statistics dealing with carcinoma of the stomach and with carcinoma of the œsophagus. Greater precision in this respect is most desirable.

Carcinoma of the fundus and of the cardia is of relatively frequent occurrence. In a series of 50 cases of primary carcinoma of the stomach in the autopsy records of the Peter Bent Brigham Hospital, reported by Duggan (5), 8 per cent occurred at the fundus and 12 per cent at the cardia, that is, in 20 per cent of this series the growth was located in the region of the gastro-œsophageal junction. Spriggs (22) reports 25 cases of gastric carcinoma of which 16 per cent occurred at the cardia. In Welch's analysis of 1,300 cases of malignancy of the stomach, 104 (8 per cent) were situated at the cardia and 19 (1½ per cent) at the fundus (12). In Walton's series (25) of 150 cases of gastric carcinoma, 60 (10.6 per cent) occurred at the cardiac end. In Taylor and Miller's series (23) of 182 cases of gastric malignancy, in 10 per cent of the cases the tumor growth began at the fundus or cardia. Of 551 cases of carcinoma of the stomach operated on at the Mayo Clinic (1918–1920) reported by Hartman (7), 39 (7 per cent) were found to be at the cardia. Walton (25) quotes Meyer to the effect that carcinoma of the cardia forms 50 per cent of all cases of carcinoma of the œsophagus. Vinson (24) reports 154 cases of œsophageal cancer of which 62 (40 per cent) began at the cardia and secondarily involved the lower œsophagus. Lilienthal (14) states that malignant tumors of the œsophagus are most frequent at the cardia.

SYMPTOMS

The symptom-complex of carcinoma of the lower œsophagus, of the cardia, or of the fundus is not in each case a clear-cut entity, varying with the situation of the lesion, but is very similar in all three situations. Nor is it sharply distinct from the picture presented by such conditions as cardiospasm, spasm of the œsophagus, carcinoma of other parts of the stomach, etc. It is only by very careful investigation of all cases complaining of suggestive symptoms, and a thorough understanding of the difficulties in examination due to the anatomical situation of the lesion and of the pitfalls arising from the limitations of the various methods of diagnosis at our disposal, that the number of undiagnosed cases will be reduced to a minimum.

The symptoms of carcinoma of the fundus are very often referred to the œsophagus (Paluguay, 17) while symptoms of cancer of the cardia are generally gastric in nature (Walton's Surgical Dyspepsias). Frequently carcinoma beginning at the fundus gives rise to symptoms which point to the œsophagus as the offending organ and the associated spasm of some portion of the terminal œsophagus leads, even after careful but incomplete examination, to a diagnosis of cardiospasm or spasm of the œsophagus. On the other hand, the symptoms may suggest a gastric origin and X-ray examination of the stomach may reveal an irregularity of the duodenal cap, which in this case is only an expression of the increased irritability of the stomach. In this manner only the associated condition is disclosed, and the true disease is overlooked and allowed to go on until cachexia and marked loss of weight make the diagnosis more obvious. One must bear in mind the possibility of a gastric carcinoma in the

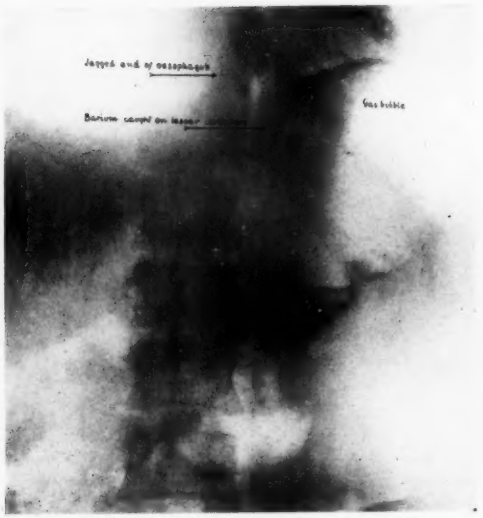

Fig. 1. Case 1. The stomach is partly filled. Note the smallness of the stomach and the irregularity of the lower end of the œsophagus. The barium is caught in the lesser curvature near the cardia, and the small gas bubble is above and to the right of the barium rest.

Fig. 2. Case 1. Horizontal position. The fundus is filled. Note the filling defect near the cardia.

presence of œsophageal symptoms, which may be present early and are usually present in advanced cases.

MODE OF ONSET

Albu (1) states that in every case of gastric carcinoma, there is a symptomless latent period of several months' duration and that the initial stage at which the patient becomes aware of the disturbance may be considered the second stage of the disease. Especially is this true of carcinoma of the fundus, corpus, and of the lesser curvature. Friedenwald (6) divides gastric carcinoma into two groups, according to the manner of onset. The onset of symptoms is sudden in a large proportion of cases, and is gradual in a

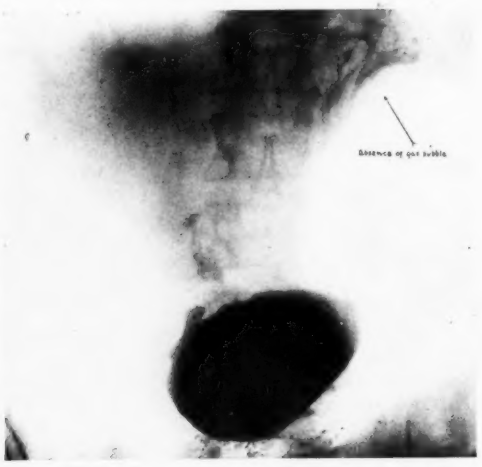

Fig. 3. Case 2. Note that there is no gas bubble present.

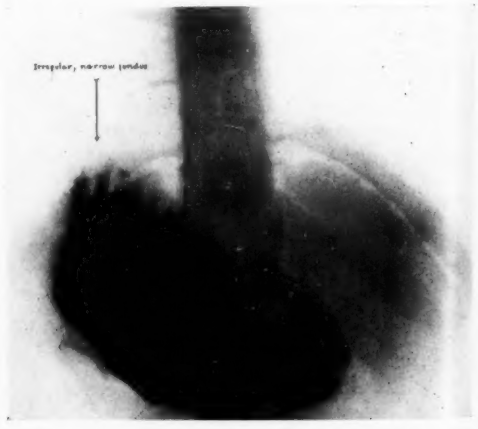

Fig. 4. Case 2. Horizontal position. Note the narrow irregular fundus.

smaller number in which the cancer has developed from a pre-existing ulcer. In his series of 1,000 cases of gastric cancer, a history of previous digestive trouble was present in only 23 per cent of his patients, while the onset was sudden and acute in 77 per cent. Deaver (4) also describes two similar clinical types of gastric cancer, one with history of long duration, beginning with ulcer symptoms which later change to those of carcinoma, and a second group in which the onset is insidious with vague symptoms of indigestion and epigastric distress and is rapidly progressive. Walton (25) maintains that the onset of symptoms of cancer at the cardia is nearly always insidious and the symptoms are generally gastric in nature.

The symptoms of which the patients usually first become aware are inconstant, indefinite, and often transitory; occasionally they are permanent.

Loss of appetite, partial or complete, is a fairly constant symptom. It was present in 89 per cent of the cases in Friedenwald's series. In 5 cases of cancer of the cardia, fundus, and lesser curvature near the cardia reported by Soulié (21), loss of appetite was present in 4 cases.

Gas eructation is a prominent and early symptom in carcinoma of the cardia (Albu, 1; E. I. Spriggs, 22). Albu also mentions as early symtoms, bitter taste in the mouth, regurgitation of small quantities of food or sour liquid, a sense of tension in the stomach, and rapid satiation.

Dislike of certain articles of food, particularly meat, is a common symptom. This may at first be inconstant. Nausea is occasionally present.

Dull pain is occasionally present but, as indicated, severe pain is frequently only a comparatively late symptom. It is usually drawing in character and radiates from the stomach in various directions, especially to the back and shoulders. It occurs independently of meals, and may vary in the same patient. Albu believes the pain to be due to the drawing of the serosa into the tumor mass or to adhesions with neighboring organs. In Friedenwald's series, pain was present in 93.1 per cent of the cases and as an early symptom in 84 per cent. In carcinoma of the cardia the discomfort or pain may be felt to the right of the epigastrium, behind the sternum, or in the back (Spriggs). The pain in the epigastrium may go through to the back. It comes on shortly after, or even during, every meal and is persistent. It differs from pain occurring in carcinoma limited to the œsophagus in that it is present after meals and is not caused by the passage of food through the œsophagus. Very severe pain usually indicates a relatively widespread growth and adhesions to the surrounding structures (Walton).

Vomiting is a constant symptom only in cancer of the pyloric region. Regurgitation of actual food is more characteristic of œsophageal cancer.

Hæmatemesis occurred in 22.7 per cent of Friedenwald's series.

Dysphagia may be caused by the direct obstructing effect of the growth if situated at the cardia, or when malignancy of the fundus has spread to the lower œsophagus, or, in either case, indirectly, by the associated spasm which may be present even before the growth is large enough to cause obstruction. At this stage the picture assumes definite characteristics of œsophageal disease. Dysphagia occurring in a patient over 40 years of age is a symptom of grave importance. In 78 per cent of cases in Friedenwald's series difficulty in swallowing appeared early. In two cases reported by Paluguay, the onset of dysphagia was sudden, with remissions of short duration. Both cases were associated with spasm, which probably explains the sudden onset and intermittent character. A slowly developing dysphagia progressively becoming worse, with remissions occurring only at first, if at all, should raise a strong suspicion of the presence of malignancy of the œsophagus or the region of the gastro-œsophageal junction. An apparent improvement in the condition, consisting of a temporary disappearance of the dysphagia in a well-developed case, should not be misleading. (The degree of dysphagia increases with the progress of the growth, until occlusion of the lumen finally occurs. This may be followed by pressure necrosis and disintegration of the central tumor mass, with consequent temporary diminution of the dysphagia.) At first, occasional dysphagia is brought on by swallowing a large, hard, and rapidly chewed bolus. Soon even very carefully masticated food is swallowed with difficulty but may be washed down by fluids. Ultimately it becomes impossible to get solids down even with the aid of fluids and finally even fluids cannot pass. There is usually an associated sense of pressure behind the sternum, which may be moderate in degree or quite severe. In cancer of the œsophagus, it is only very rarely that the onset of dysphagia is sudden and is then probably due to the secondary spasm. In this connection Ridder's observation (20) is of interest: "It is very characteristic of carcinoma of the œsophagus that narrowing can be demonstrated earlier subjectively than objectively by means of the sound." When remissions occur they are usually of short duration.

As the case progresses, other symptoms may develop: regurgitation, cough, hiccough, and choking sensations.

Rehfuss (19), quoting Pratt, states that excessive salivation is often an early symptom of malignancy of the lower œsophagus. Howarth (9) makes a similar observation.

Hoarseness and aphonia due to pressure of secondary enlargements upon the recurrent laryngeal nerve are fairly frequent findings. Vocal changes occurred in 18 out of 236 cases reported by Sokata (quoted by Lilienthal, 14).

Walton mentions lack of strength and energy as early symptoms of carcinoma of the cardia.

Loss of appetite, gas eructation, pain, and dysphagia are the only frequent and early symptoms. Only the last is suggestive of lesions of the œsophagus, cardia, or fundus.

EXAMINATION OF PATIENT

The patient presents a definite picture of malignancy only very late in the disease, and it is therefore advisable to omit a description of a so-called typical case, but rather to discuss the individual signs, their relative frequency, and importance.

Marked malnutrition and cachexia, as has already been stated, are late manifestations, and according to Albu should not constitute an important part in the carcinoma picture. In young people, cachexia is often entirely absent (Wheeler, 26) and in carcinoma of the lower œsophagus marked cachexia is rarely seen (Howarth, 9).

Fever is comparatively rare in gastric carcinoma. It is intermittent in character, lasting weeks or months (Albu). In young individuals fever occurs earlier and is more frequent (Wheeler).

Enlargement of the supraclavicular glands is a comparatively infrequent finding in malignancy of the stomach, and when present indicates marked advance of the disease. In 1500 cases reported by Albu, such enlargement was present in only 12. Walton, however, reports its occurrence in 3 per cent of gastric cancer cases.

LABORATORY METHODS

The test meal does not give conclusive evidence for or against the presence of malignancy. This is particularly true of carcinoma of the cardia and fundus, since gastric retention does not occur in such cases.

Achlorhydria does not necessarily indicate malignancy, while on the other hand, normal acid values and even hyperacidity may be present. Horak, quoted by Rehfuss, states that in 20 per cent of the cases, acid is present in the stomach either in the beginning or constantly. "Although free hydrochloric acid, and later the combined, is very often absent in cancer, absence of free hydrochloric acid occurs in benign disease of the stomach, while its presence does not exclude carcinoma." Kuettner (13), Hurst (10), and others express the same conviction. Hartman gives the following figures for 551 cases of gastric carcinoma occurring at the Mayo Clinic during a period of 3 years. Ignoring the location of the tumor, achlorhydria occurred in 53.72 per cent, hypochlorhydria in 15.78 per cent, normal values were present in 17.42 per cent, and hyperchlorhydria in 4.53 per cent of the cases. Normal or hyperacid values were therefore present in 21.95 per cent of all cases in the series, while achlorhydria was present in little more than half of the cases. Hartman's figures for achlorhydria occurring in cases of cancer at the cardiac end are a little higher—61.54 per cent. These figures are based on the highest readings obtained during fractional gastric analyses. In Lloyd's series of 50 cases (15), 17 per cent had normal or hyperacid values in the resting juice, and the fractional analyses brought the figures up to 20 per cent. Taylor and Miller (23) give the following figures for 182 cases of gastric cancer. Acid determinations were done on the 45 minute fraction of the Ewald test meal. Achlorhydria was present in 68.4 per cent, hyperchlorhydria in 4.5 per cent, normal acidity in 14.8 per cent, and low acidity in 12.9 per cent of the cases. (Normal and hyperacid values in 19.3 per cent.) Friedenwald's series of 1,000 cases showed a much higher proportion with achlorhydria (89 per cent). He draws attention to the fact, however, that there is a natural tendency to a diminution of gastric secretion after the fiftieth year and that it is not uncommon to observe this condition as a manifestation of old age. "There should not, therefore," he states, "be too much stress placed on this finding as evidence of the presence of malignancy." Even though achlorhydria is a somewhat frequent finding in carcinoma of the fundus and cardia, it is not a sufficiently constant finding to make it a valuable aid in diagnosis. According to Albu, however, the rule in fundus carcinoma is the absence of free hydrochloric acid. In marked contrast with this statement stand the figures of Hartman, who found free acid present in 38.46 per cent of 39 cases of cancer at the cardiac end of the stomach.

Secondary anæmia, though frequently present in cancer of the stomach, is always a late sign (Albu). It may, however, be absent even in advanced cases. Hurst (10) reports 2 cases of 95 per cent and 103 per cent hæmoglobin respectively.

In 1 of the 2 cases reported in this paper the blood picture was normal. According to Hirschfeld (8) anæmia associated with leucocytosis in the absence of fever or infectious diseases should lead one to suspect malignancy.

Occult blood in the stools, is a very constant and early finding. Tarry stools occur much less frequently (in 18.9 per cent of Friedenwald's series). Occasionally occult blood may be temporarily absent from the stool and it is therefore necessary to repeat the test on several occasions.

Thus subjective and objective symptoms as well as laboratory findings are insufficient to establish early diagnosis. Although some of the symptoms enumerated are very frequently present in carcinoma of the region of the gastro-œsophageal junction, their presence does not constitute proof of such a lesion. They should serve, however, to arouse the suspicions of the clinician and to prompt him to exhaust all methods of examination before declaring that a malignant lesion is not present.

According to Chevalier Jackson (11), there are only two reliable methods of diagnosis in carcinoma of the œsophagus: the X-ray and œsophagoscopy. The latter is unfortunately of little value in the diagnosis of cancer of the cardia or fundus, even in the presence of extensive invasion.

X-RAY DIAGNOSIS

From the roentgenologic point of view there are two pathological groups of fundus and cardia cancer: (1) infiltrating flat growths, associated with shrinking (scirrhous type); (2) the fungating, cauliflower type of growth. The medullary type of tumor, which in the rest of the stomach gives rise to a filling defect, is seen in the fundus as a tumor shadow jutting into the gas bubble, which may divide the barium stream as it enters the stomach. This type of tumor growth gives comparatively little difficulty in diagnosis. It is the flat, squamous cell type that is troublesome. To diagnose cancer at the cardia, we must depend upon irregularity of the cardia and of the terminal portion of the œsophagus as direct signs.

The main difficulties in the X-ray diagnosis of cancer of the fundus and cardia are those caused by (1) the location of the growth. In the case of carcinoma situated at the fundus, the lesion may be overlooked (unless it is a medullary one and encroaches upon the gas bubble) because the barium suspension does not fill the fundus in the upright position, nor do peristaltic waves ordinarily traverse the upper pole of the stomach. In the ordinary, routine positions of examination, cancer of the cardia may be overlooked because the liver shadow hides the subdiaphragmatic portion of the œsophagus (Ridder, 20), and in the horizontal position because the last portion of the œsophagus and with it the cardia are covered by the filled fundus (Paluguay, 16). (2) Carcinoma of the fundus, as has been previously stated, is frequently associated with spasm of the cardia or lower œsophagus, and that of the cardia with spasm of the lower œsophagus. These associated spastic manifestations may mask the more serious condition lower down in the gastro-intestinal tract. It is necessary, therefore, when ordinary methods fail, to resort to special methods of X-ray examination in suspected cases.

If the barium suspension enters the stomach without being arrested in its downward course, or without disclosing some irregularity of the areas under inspection, the barium paste should be tried. Very careful screen examination, in addition to skiagraphy, is essential. The patient is examined in the upright left oblique position to begin with. This position brings into view the œsophagus in the greater part of its course. It is essential to have the patient take single, small sips of the opaque meal. Very often a large mouthful of barium suspension is arrested at the cardia, while a small quantity will trickle into the stomach without any difficulty. The swallowed barium is followed in its passage through the œsophagus, particular attention being paid to the manner of its entry into the stomach. There is frequently partial or complete arrest of barium at the cardia, and in the case of fungating tumors of the lesser curvature near the cardia, a forking of the barium stream or the presence of a tumor shadow silhouetted against the background of the gas bubble, may be present. When complete arrest of barium occurs at the lower end of the œsophagus, in spite of taking small quantities at a time, spasm of the cardia or of the œsophagus is diagnosed. Absence of marked dilation or tortuosity of the œsophagus will tend to rule out true cardiospasm as opposed to spasm of the cardia or of the œsophagus. Smoothness of the contours of the lower end of the barium-filled œsophagus does not rule out malignancy, since spasm occurring oral to a lesion may be situated in an entirely normal portion of the œsophagus. Paluguay (16) quotes Assman to the effect that in idiopathic dilatation the subdiaphragmatic segment of the œsophagus often lies transversely, and is directed to the left, while in carcinoma it follows an almost vertical direction and there does not occur any greater lateral deviation to the left than that usually present. Howarth (9) and Rehfuss (19) find that the

triangular space formed when the œsophagus turns forward and to the left to enter the diaphragm is often obliterated in malignancy.

If, in spite of slow sipping, the barium does not enter the stomach and the œsophagus is not found to be markedly dilated or tortuous, that is, if signs of long-standing obstruction are absent, the patient should be re-examined after administration of antispasmodics to the limit of tolerance. In the words of Paluguay (17), "It is only when the passage of barium through the cardia occurs, that an examination of this region can be made, and a decision be made whether spasm only is present or an organic lesion in addition. Only the presence of smooth contours and a normal behavior of the cardia mechanism in the spasm-free stage permits one to exclude carcinoma of the cardia."

Shrinking of the stomach and its displacement upward and to the left may be present in scirrhous carcinoma of the stomach (Carman, 3). Diminution in size of the stomach in cancer of the cardia is also mentioned by Albu. Both signs were present in one of the cases reported here.

Absence of the gas bubble is an important sign. Infiltration of the cardia may give rise to inefficiency of the cardiac sphincter resulting in escape of the gas normally filling the fundus. Thus a permanently absent gas bubble is evidence of patency of the cardia and points to the possible presence of infiltration (Bergmann, 2).

The patient should next be examined in the horizontal position. For proper examination of the fundus it is necessary to have the stomach well filled. Normally the fundus fills the dome of the left diaphragm and lies in close apposition to it. Its upper limit traces a smooth wide arc. Occasionally this contour is dentate, this appearance probably having the same significance as the dentate appearance of the greater curvature due to contracting of the muscularis mucosæ. This irregularity must not be confused with that produced by a local lesion. In such cases the irregularity is not regularly dentate and does not follow the sweeping arch of the fundus; the transverse diameter of the fundus is also much narrower than is usual (due to encroachment of the tumor upon the lumen of the stomach, or to shrinkage in scirrhous forms).

If careful examination as outlined above, fails to reveal the presence of a lesion, the region of the cardia should then be thoroughly examined. The cardia is not brought into view for careful inspection in ordinary methods of examination. The reasons for this have already been mentioned. Ridder advocates the Stuertz position. The stomach is filled with gas, and the patient fluoroscoped in an oblique position, the rays being directed from the right, posteriorly and above, to the left anteriorly and below. An unobstructed view of the cardia and terminal œsophagus is obtained in this manner. According to Paluguay carcinoma of the cardia can be recognized even in cases showing but little change in the stomach wall, but in which the normal cardia mechanism is disturbed. There is a persistent trickling of barium through the cardia, and as a rule, the outlines of the opague meal, as it passes through the cardia, are seen to be irregular and jagged. It is only, however, the irregularity of the contrast silhouette in the region of the cardia, with the patient in the Trendelenberg position, that can be considered as direct X-ray evidence. Payr-Hohlbaum (18) points out that in cancer of the cardia the upper pole of the stomach is an unusually great distance away from the diaphragm.

The direct signs of gastro-œsophageal cancer are:

(1) Tumor shadow bulging into gas bubble; (2) irregularity of the barium contour as it passes through the cardia; (3) splitting of barium stream on entering stomach.

The indirect signs are:

(1) Spasm of the œsophagus or cardia; (2) disturbance of the cardia mechanism (Paluguay); (3) absence of the gas bubble; (4) shrinking of the stomach; (5) drawing of stomach upward and to left; (6) increased distance between the upper pole of the stomach and the diaphragm; (7) narrowing of the fundus; (8) obliteration of the triangular space mentioned by Howarth and Rehfuss.

CASE 1. Mr. I. H., white, aged 40 years, was first seen May 18, 1925. He complained of: (1) difficulty in swallowing solid food; (2) belching of gas; (3) anorexia; (4) loss of weight; (5) marked salivation; and (6) hoarseness of voice.

In June, 1924, the patient complained of indefinite gastric symptoms and some difficulty in swallowing solid food. At the time, the condition was diagnosed as duodenal ulcer on indirect X-ray evidence. In spite of treatment the symptoms became more troublesome, particularly the difficulty in swallowing. The history of the next few months can be summarized as follows: the patient became progressively worse, and was, during this period, examined *de novo* by several physicians and a diagnosis of cardiospasm was made in all instances. The condition had progressed without remissions.

At the time of examination, solids could not be taken at all. There was no vomiting, pain, or regurgitation of food. Belching of gas and marked anorexia were prominent symptoms. The patient had lost 20 pounds in weight. He had always led a continent life and had been in good health until the summer of 1924.

Physical examination. The patient was a well developed male; somewhat pale; with evident loss of weight. The pupils reacted to light and accommodation. There were many carious teeth; the tongue was coated. No palpable supraclavicular glands were present. The lungs were

negative. The pulse was 84; regular; with good volume and tension. Systolic blood pressure was 125; diastolic pressure was 80. The heart findings were negative. The abdomen was full and soft. No organs or masses were palpable. There was no tenderness. Lymphatic, genito-urinary, and nervous systems were negative. Rectal examination was negative except for hæmorrhoids. The urine was essentially negative. The stool showed occult blood on several occasions. The blood Wassermann was negative. In the gastric analysis, the tube failed to enter the stomach.

Bougies were passed without difficulty down to 45 centimeters from the teeth. No obstruction was met with until the cardiac end of the œsophagus was reached.

Direct œsophagoscopy on July 2, 1925, led to a diagnosis of stricture of the œsophagus. The pathological report of biopsy specimen taken from the lower end of the œsophagus was "There is no definite evidence of inflammatory reaction or of neoplastic proliferation."

X-ray examination. The patient was instructed to swallow barium in small sips. There was some delay at the cardia; the œsophagus was only slightly wider than normal. The lower end of the column of barium in the œsophagus showed a fine irregularity. Barium entered the stomach in a constant, small trickle and was caught in a small irregularity of the gastric wall on the lesser curvature just below the cardia. The retained barium remained there throughout the examination. The stomach was very small and lay entirely to the left of the spinal column. In the horizontal position a walnut-sized filling defect was seen on the lesser curvature near the cardia. This defect corresponded with the area of irregularity observed in the upright position.

On the grounds of persistent dysphagia, without remissions, the presence of blood in the stool, and the X-ray findings, diagnosis of carcinoma involving the lesser curvature and œsophagus was made. Three months later, because of increasing difficulty in taking nourishment and the resulting marked emaciation, surgical intervention was decided upon. The operation was performed on August 27, 1925. " . . . it was with difficulty that the dome of the diaphragm was reached. There was a suspicious hardness around the lesser curvature of the stomach and the cœliac axis, probably invasion from the lower œsophageal growth. The fundus of the stomach was firmly fixed . . ." A Witzel gastrostomy was done. A snipping from the lower end of the œsophagus was reported as "undoubtedly carcinoma"; one from the growth of the lesser curvature was too small for diagnosis.

The patient did well for some time, then gradually declined and died on November 26, 1925.

CASE 2. Mr. S. H., white, 45 years old, was first seen on June 1, 1926. He complained of pain behind the lower end of the sternum on eating; difficulty in swallowing solids, accompanied with pain; eructation of gas associated with pain; increased salivation; loss of weight and appetite. His illness began 2 years previously. He first complained of a little pain behind the lower end of the sternum with every meal. Frequently, only the first swallow brought on pain and the pain disappeared with the taking of additional food. The pain did not radiate. It was relieved by bicarbonate of soda. There were gas eructations; but there was no nausea or vomiting. The condition persisted for about 2 months and was followed by a remission of 2 months. During the subsequent 18 months, the patient suffered from recurrent attacks of pain coming with the first swallow and disappearing with the taking of additional food. During the preceding 6 months the pain had increased in severity and was not relieved by food or medicaments. At the time of the examination the patient complained bitterly of the pain behind the sternum, which now came through to the back, and of painful gas eructations. Increased salivation was quite marked and a very troublesome feature. The appetite was poor, and because of the pain the patient feared to eat. The bowels were sluggish; there was at no time diarrhœa or melæna. The weight had gone down from 130 to 112 pounds.

The patient had undergone three complete and separate examinations, with the following results. In March, 1926, a diagnosis of duodenal ulcer was made. He was put on Sippy diet. He was better for 2 weeks with a subsequent return of the symptoms. In April, 1926, an examination was entirely negative for organic disease. A diagnosis of gastric neurosis was made. In May, 1926, a diagnosis of spasm of the lower œsophagus was made.

Personal history. The patient has suffered from asthma and constipation for 20 years. Asthma was cured 2 years ago. With these exceptions he had always been well. The family history revealed nothing of interest.

Physical examination. The patient showed signs of marked loss of weight, but he was not cachectic. The pupils reacted sluggishly to light and accommodation. He had several capped and carious teeth; there was a moderate degree of pyorrhœa. The tongue was coated. The pulse was 100, regular, with fair volume. Systolic blood pressure was 130; diastolic, 80. Heart and lungs were negative. The abdomen was flat. There was slight tenderness over the entire abdomen. No masses or organs were palpable. Lymphatic (no enlarged supraclavicular glands), genito-urinary, and nervous systems were negative. Rectal examination was negative. In a gastric analysis, the fasting content was 10 cubic centimeters. There were no food remnants and no blood. Free hydrochloric acid was 0; total, 16; at end of 1 hour 20; total, 40.

The urine was negative. Stool was dark brown and formed, showing a faint trace of occult blood. Blood Wassermann was negative. Hæmoglobin was 90 per cent; red cells were 4,900,000; white cells, 7,200—a normal blood picture. A small specimen from lower end of œsophagus revealed inflammatory cells and a few suspicious cells, but no definite evidence of carcinoma.

X-ray examination. Barium suspension entered stomach without being delayed at the cardia. Fundus was narrow and rigid; the barium could not be forced into it by pressure from below. A small quantity of barium remained caught, and was distributed in an irregular manner in the fundus. The gas bubble was absent but as the patient swallowed, a little air was seen in the fundus, this, however, quickly left the stomach and was belched up. Whenever that happened, the patient complained of pain behind the sternum. Peristalsis was active. The cap filled well. The stomach was empty in 6 hours. Examination of colon revealed 72-hour stasis. Diagnosis: infiltrating growth of fundus, involving cardia and causing insufficiency.

On July 29, 30 and 31, the patient passed tarry stools. By this time the patient was confined to bed, and had lost considerable weight. He was taking very little food because of the pain and was rapidly failing. On August 5, a Witzel gastrostomy was done. Operation revealed carcinoma of the fundus involving the cardia and extending posteriorly to the spine, and adherent to it. Patient did not stand the operation well, and died on August 31, 1926.

CONCLUSIONS

In both cases, errors in diagnosis were made several times. A survey of the literature on the subject reveals the fact that such errors are quite common. The apparent reasons for this have already been considered. If it is kept in mind that

lesions of the cardia may give rise to œsophageal and gastric symptoms, and lesions of the fundus to œsophageal symptoms, much could be accomplished toward diminishing the number of undiagnosed cases, or toward making the correct diagnosis earlier.

Carcinoma of the fundus may give rise to œsophageal symptoms only. Such cases are particularly liable to errors in diagnosis, since all attention is centered on the œsophagus; investigation reveals nothing but the presence of œsophageal spasm, and the disease is labeled functional. Œsophagoscopy may reveal a little irregularity or bulging of the mucosa, but, a specimen taken even from an advanced case may show no signs of malignancy. The spread of carcinoma is submucous and unless a negative specimen includes a portion of the submucosa, no value can be attached to the findings. Lesions of the fundus may, by extension, involve the œsophagus, and those of the œsophagus may, in a similar manner, involve the fundus. Evidence is not lacking that the cardia does not serve as a barrier to the advance of malignant growths, either from the fundus upward or from the œsophagus downward. Furthermore, there is anatomical evidence that such extension does occur, and is quite frequent.

Malignant disease of the gastro-œsophageal junction is so unlikely to be limited to only one of the three situations under discussion, either in actual organic involvement, or in the development of symptoms, that it appears to be unwise to speak of carcinoma of the fundus, of the cardia, or of the last portion of the œsophagus. There appear to be sufficient grounds for referring to cancer of these areas as gastro-œsophageal cancer. A further advantage in the use of this term is that it simplifies the problem of classification, and incidentally makes the literature on the subject more readily available. The use of such nomenclature is sanctioned by precedent—the term ileocæcal tuberculosis.

SUMMARY

1. About 15 per cent of all malignant gastric lesions are situated at the fundus or cardia.

2. There is no definite symptom-complex pathognomonic of carcinoma of the fundus or cardia.

3. The tendency of malignant lesions of the cardia and fundus to give rise to gastric and œsophageal symptoms respectively is responsible for many errors in diagnosis.

4. Dysphagia is the most important symptom and may not be directly due to the lesion, but to an associated spasm. A slowly developing dysphagia, progressively becoming worse with remissions occurring early, if at all, is strong evidence in support of a diagnosis of malignancy.

5. Loss of appetite, gas eructations, and pain are the most frequent and early symptoms, but they are present in so many other conditions that they acquire only secondary importance.

6. Malnutrition, cachexia, and loss of weight are late manifestations, and their absence does not constitute evidence against malignancy.

7. Enlarged supraclavicular glands are rarely present, and if present occur late.

8. Achylia and anæmia are not reliable signs, but are of secondary importance. If present, anæmia is a late manifestation.

9. Occult blood in the stool is an almost constant finding.

10. Œsophagoscopy is of little or no value as an aid to diagnosis except in carcinoma beginning in the lower œsophagus, particularly in the presence of malignant ulceration.

11. The most important method of diagnosis is careful radioscopic and radiographic examination in all positions. The direct and indirect signs are enumerated.

12. The use of the term gastro-œsophageal carcinoma is suggested for malignant lesions involving primarily the terminal œsophagus, cardia, or fundus.

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EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

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SURGICAL TREATMENT OF THE NEURALGIAS

SINCE Spiller suggested section of the posterior root of the gasserian ganglion in 1899 for the surgical treatment of trigeminal neuralgia, no new principle of treatment has been introduced. There have been modifications in technique, but only with the purpose of reducing postoperative mortality and morbidity. Experience with section of the larger nerve trunks and avulsion and section of the peripheral nerves has demonstrated how futile such measures are to produce anything but temporary alleviation of symptoms. The injection of alcohol by various methods which afforded temporary relief was a valuable addition to the treatment particularly in early cases and in those in which the physical condition of the patients rendered surgical procedures too hazardous. With the lapse of time, however, the conception has been confirmed that in order to effect permanent cure the trigeminal nerve must be interrupted between the gasserian ganglion and the brain stem.

When glossopharyngeal neuralgia was recognized and established as a clinical entity, the failure of operations on the nerve trunks to bring about permanent relief led Adson to adopt a procedure analogous to that practiced in trifacial neuralgia, namely severing the glossopharyngeal nerve proximal to the superior and petrous ganglia. Although sufficient time has not elapsed to establish evidence of permanent cure, the relief following the procedure, extending in one instance over 20 months, and experience with the analogous procedure in trigeminal neuralgia, bespeak success.

Because of the satisfactory results of these operations, especially in cases of trigeminal neuralgia, section of the posterior root for complaints resembling trifacial neuralgia became inevitable. The argument was advanced that if the face were anæsthetic, no pain would be felt. In some instances the differential diagnosis was confusing; in others there were only slight resemblances to the classical syndrome. Critical study of this group of cases has demonstrated that as a rule the pain is pulling, drawing, deep-seated, and constant in character. If paroxysms occur they are infrequent and are likely to be prolonged for hours at a time. The complaints are as a rule bizarre. It has been emphasized repeatedly that trigeminal neuralgia is a disease of unswerving constancy and that variations from the accepted syndrome constitute different forms of disease demanding different methods of treatment. Most of these cases are to be classified with migraine, the psychoneuroses, the changes incident to senility, and entities, the nature of which has not yet been determined. It is now commonly agreed that not only is operation in these cases ineffective,

but in certain instances it aggravates the condition. Even cervical sympathectomy after previous section of the posterior root of the gasserian ganglion has failed to relieve the patient's complaint.

A group of patients who have received less consideration are those suffering from the disability incident to the pain and paresthesia following herpes ophthalmicus. Adson reported 2 cases in which he cut the posterior root of the gasserian ganglion without success. The explanation that failure resulted because of involvement by the underlying process of structures within the brain-stem has recently been corroborated by Lhermitte and Nicolas whose contribution shows that the essential pathological change of herpes may involve simultaneously the ganglion and the central grey matter.

That the application of the principle of section of the posterior root for the relief of other types of pain has not been successful does not detract from the original success of the procedure but merely limits its applicability to one form of human scourge. It has become obvious that section of the respective posterior root is the only curative measure for trigeminal and glossopharyngeal neuralgia and conversely that this type of operation is effective only in cases of true paroxysmal neuralgia.

JOHN B. DOYLE.

WHY SURGERY IS INDICATED IN HYPERTHYROIDISM

WITHIN the past two decades, our knowledge of the glands of the body, both duct and ductless, has markedly advanced. This is especially true of the thyroid gland. We now associate the pathology of the thyroid with the clinical symptoms of disease of this gland, and the clinical symptoms with the metabolic rate. The etiology of goiter is very obscure, there being four theories regarding it: (1) The earth and water and (2) the toxic-infective theories, (3) the theory of the absence of iodine from food, and (4) that of multiple causation in relation to general hygiene. Since the cause of goiter is unknown to us, naturally the medical treatment is non-specific. It is true that improvement may result from many different forms of treatment; but it is equally true that improvement, often absolute cure, will follow in a certain small per cent of cases even though no treatment is instituted. This latter is especially true of cases of hyperplastic goiter. Unfortunately most of the patients die before the spontaneous "cure" occurs.

Simple endemic goiters, as well as those of adolescence and pregnancy should be treated medically. Colloid goiters, due to iodine insufficiency, can usually be cured by the administration of iodine or thyroxin. To the experienced thyroid surgeon they become surgical only in the presence of cyst formation and pressure symptoms.

There is no doubt that the epithelial cells of the thyroid can be altered and even destroyed by the action of the X-rays, and thus their function can be modified and even abolished. But according to those best informed on this subject, the X-ray is curative in a very small number of cases. Crile, judging his results by means of the respiratory exchange, places the efficacy of radiotherapy between that of simple ligature and that of resection of the gland. One must not forget that the action of the rays is markedly cumulative; that a result apparently favorable at the beginning may eventually turn out to be excessive; that the adhesions after radiotherapy are often more marked than those following surgical intervention; and that when these patients do come to operation, what may have been a comparatively easy surgical procedure is made very difficult.

Surgical treatment offers to the patient suffering from hyperthyroidism, either from exophthalmic goiter or toxic adenoma (nodular goiter with hyperthyroidism—Rienhoff), by far the best chance for recovery. A conservative estimate of results after 5 years shows that 60 per cent of the patients are cured, 30 per cent greatly benefitted, 7 per cent improved, and 3 per cent unimproved. After the same period, a fair estimate of the medical treatment would probably be a reversal of these figures.

These 40 per cent partial or complete failures, as you choose, are explained by Richter upon the basis of the removal of insufficient gland with resulting residual symptoms and a persisting increased basal metabolic rate. In his own work he reports 93 per cent cures, patients free from any evidence of thyrotoxicosis. Undoubtedly this work of Richter will have a stimulating effect on thyroid surgery and the percentage of definite cures.

The administration of iodine in the form of Lugol's solution as advocated by Plummer, as a pre-operative procedure in exophthalmic goiters, is routine in all goiter clinics. Its effect is so remarkable as to cause it to be considered a specific in the pre-operative preparation of exophthalmic goiter patients. It is not to be considered as a curative agent, for its effect is transient. When the maximum effect of the drug is obtained, that is, an artificial remission, usually within 10 days, as manifested clinically and by the basal metabolic rate, your patient is ready for surgery. Surgery should not be delayed as the efficacy of iodine diminishes with each subsequent course.

The use of iodine in the pre-operative preparation of patients with toxic adenomata is a debatable question. Plummer still believes that it should not be used, while Graham and Cutler advocate its use. With the large number of cases of iodine hyperthyroidism being reported, it may be wise to abstain from its use until more conclusive evidence has been offered in its favor.

Digitalis is useless for the purpose of counteracting the nervous and toxic acceleration of the pulse. Its action is entirely superfluous, because the heart is already overstimulated by the hyperthyroid condition, the only effect of the digitalis, therefore, being a toxic one. Plummer even goes so far as to state that the very definite reduction in mortality at the Mayo Clinic in patients with toxic adenomatous goiters, to less than 1 per cent, was directly due to stopping the use of digitalis. However, it should always be given in cases of circulatory troubles due to a cardiac lesion.

Our surgical patients are very exacting; they demand to know the risk; to have a scar which is scarcely visible; their recurrent nerves and parathyroids must remain uninjured; sufficient thyroid must be left for future requirements; and above all they must be guaranteed against a recurrence. In spite of all these demands, the well known goiter clinics of our country show a mortality of less than 1 per cent for all types of goiter. So in speaking of other than surgical treatment for the toxic thyroid, we should not compare but should contrast. Until the etiology of goiter is discovered, surgery is the method of treatment, and the indication for operation is the diagnosis. The case of the surgeon is ably summed up by Richter: "I have not had failures from my thyroidectomies, though I have not infrequently failed to accomplish a thyroidectomy in the first attempt."

J. E. STRUTHERS.

MASTER SURGEONS OF AMERICA

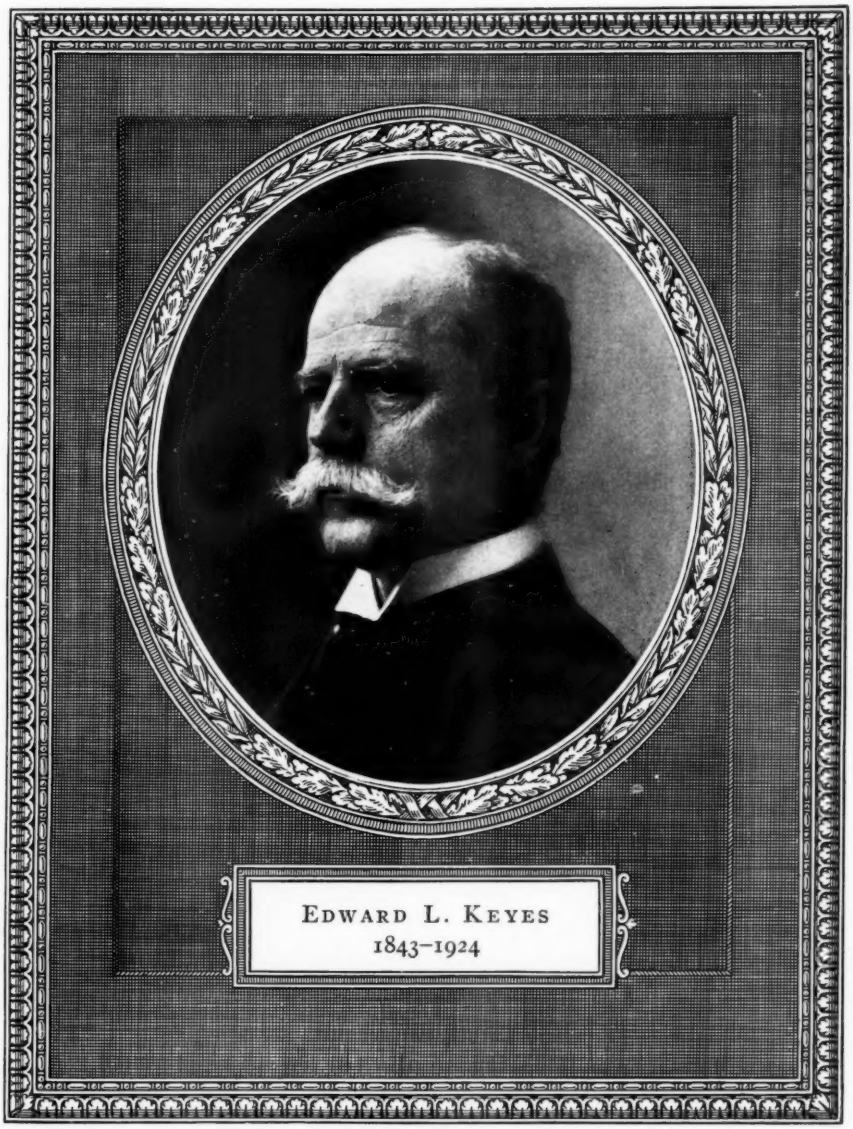
EDWARD LAWRENCE KEYES

MEN stamp their personality upon their time in one of two ways. Some leave the impress of their adventurous and romantic characteristics: they are the discoverers, the inventors, the poets. Far more numerous are those who impress their contemporaries with the very essence of their character, their industry, their intelligence, their honesty rather than by a definite invention or discovery: such are the statesmen, the educators, the scientists. The happy combination of the two is rare, yet it was found in Edward L. Keyes, A.M., M.D., LL.D., K.S.G.

Dr. Keyes was born August 28, 1843, at Fort Moultrie in Charleston Harbor, South Carolina, of Erasmus Darwin Keyes, who later commanded the Union troops at the battle of Fair Oaks and was ultimately Major-General of Volunteers, U. S. A., and Caroline M. Clarke of Brooklyn, New York. His forbears were Puritan; his education was received at Dedham, Massachusetts, and at Yale (A.B., 1863), where he rowed on the Freshman crew and was a member of the Scroll and Key Society.

After a brief staff captaincy under his father at Washington during the closing months of the Civil War, young Keyes entered New York University Medical College, graduating in the customary 2 years in the spring of 1866. Under the advice of his preceptor, the professor of surgery, William H. Van Buren, he then immediately proceeded to Paris to specialize in dermatology. After a year in Paris he returned to New York where he offered himself to Dr. Van Buren as an assistant, only to be informed that Doctors Swift and Gouley already filled all the available space but that he, Keyes, could do odd jobs if he wished. His acceptance of this humble prospect and his industry thereupon were rewarded when shortly the dispute about the invention of the tunneled urethral sound dissolved the association between Van Buren and Gouley, while Swift died, leaving Keyes as first assistant of the town's brilliant and fashionable surgeon.

Curiously enough, in view of his later surgical developments, Keyes' special qualifications as a dermatologist seem to have sidetracked him from that career as general surgeon to which the assistant of the professor at the University and the visiting surgeon to the New York Hospital might well have aspired. We find him holding the first clinic in dermatology in the United States at the



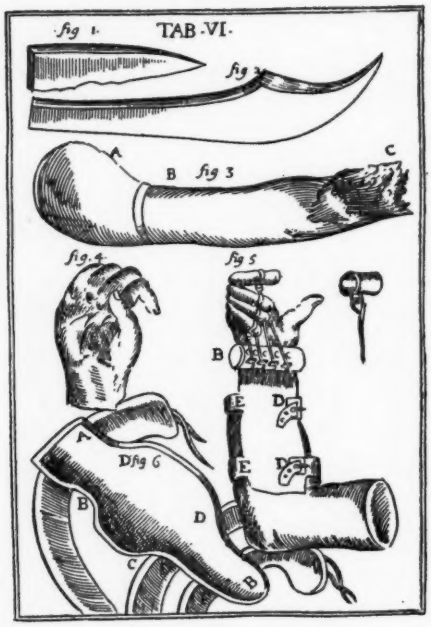
EDWARD L. KEYES
1843–1924

In his latter years, though he continued always to consider himself a general practitioner (and was once jeered at by his fellows for missing a meeting of the American Association of Genito-Urinary Surgeons because of an obstetrical case) his originality manifested itself more in the daily spoken word and in the activities of his pupils, Alexander, Fuller, Chetwood, and Keyes, Jr. The most notable contributions of these men were probably those of Fuller in originating the treatment and especially the surgery of the seminal vesicle (and incidentally the first crude theory of the metastatic origin of arthritis) and in the establishment of suprapubic prostatectomy upon its modern basis. Of these items, the ones relating to the seminal vesicle and rheumatism seem to have belonged wholly to Fuller, but the details of prostatectomy as described by Fuller were those of the operation performed by both.

So much for the inventor. The man was bigger. Though no organizer, his authorship of an accepted textbook, his pellucid honesty, his gift of precise speech, his kindliness to all, made him inevitably the founder and first president of the American Association of Genito-Urinary Surgeons. Later his gifts in oratory won him the central oration at the opening of the New York Academy of Medicine in Forty-Third Street. He served a term as Vice-President of the Academy. In the privacy of his office he was the true helper of the sick, interested far less in organization progress or individual invention than in solving the puzzle presented by each patient in his turn. Here the simple nobility of his character and his understanding sympathy gave him that hold upon his generation which is the physician's great reward. In his youth he had been isolated a month with Charles O'Connor when the latter returned from Europe with smallpox, and years after when the man who smashed the Tweed ring was dying at Nantucket and was told that the family had sent for Keyes, he said, "Don't let him come; this time I want to die."

He, himself, succumbed to the "old man's friend," pneumonia, at the age of eighty, on January 24, 1924.

E. L. KEYES.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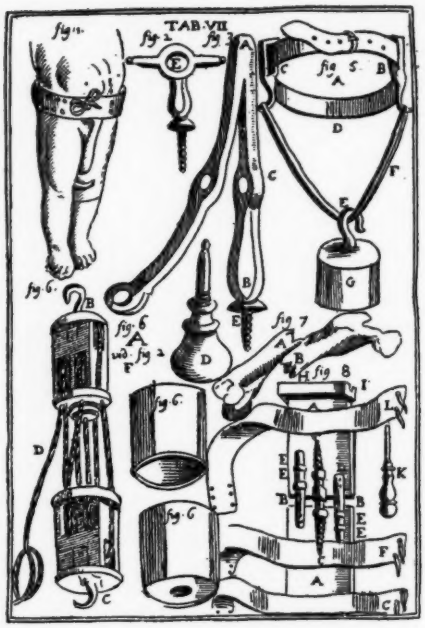
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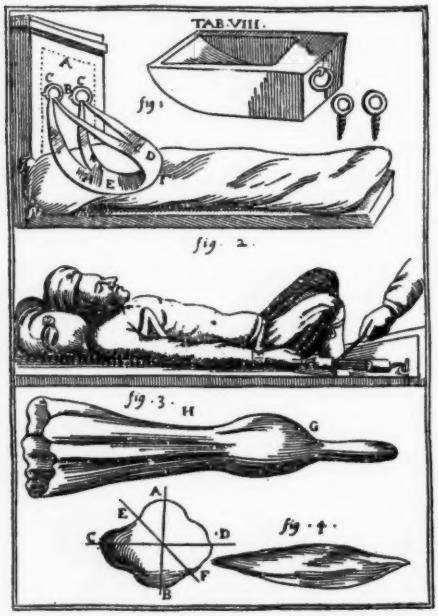
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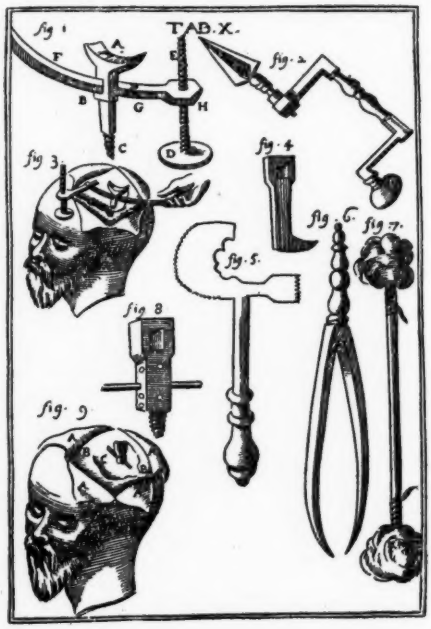
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THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

By ALFRED BROWN, M.D., F.A.C.S., Omaha, Nebraska

THE SURGERY OF FABRICIUS HILDANUS

SURGICAL "Observations" were the fashion in the literature of the late sixteenth and early seventeenth centuries. Clinical Surgical Pathology was coming into its own. For the most part these "Observations" were rather hit or miss reports of cases—usually unco-ordinated and following no definite schema. Some of them were of considerable value to surgical development, all are interesting to present day readers, peculiar and exaggerated though some of them may be, for in this lies much of their charm. Occasionally a surgeon is found who went beyond the mass of his contemporaries, and from his study and experience produced a work of more outstanding merit than the usual. Fabricius Hildanus, or, to give him his full name, Whilhelm Fabri of Hilden, belonged to the group of Master Surgeons of his time and his superiority is so evident that he has been called the "German Paré."

He was a barber surgeon but, contrary to the rule, he was also a well educated man. He first attended a school at Cologne, where he learned Latin and thus fitted himself for the study of the eminent surgical authors. When sixteen he took up the study of medicine under various wound surgeons, Dumgens, Slotanus, Solenander who was educated in Italy, and Weyer. He probably studied also under Bartisch at Metz. He went to Geneva when he was twenty-six years of age and began to practice, and the following year married Marie Colinet, who was versed in midwifery and helped him in his work. In later years, when Fabricius was away on one of his long consultation trips, his wife, with the assistance of his students, cared for his practice. With his advent in Geneva, Fabricius' reputation and practice began to grow. Though he never served actively in war he was considered one of the great wound surgeons, and his first work of importance was on burns—wherever he went he was in constant search for information and particularly postmortem and anatomical work. Among other activities he articulated a skeleton which he presented to the City Library of Berne to take the place of the one presented by Pierre Franco which had fallen apart.

Constantly moving from city to city, he nevertheless found time to write his "Observations" and his first "One Hundred" appeared at Basel in 1606. Then followed numerous other works—on gunshot wounds, war surgery, the necessity for a knowledge of anatomy, lithotomy, four hundred more "Observations," and others. His work was monumental. In his old age, when sixty-eight years had taken their toll, he felt his powers waning and, also experiencing the tortures of the gout, he withdrew to a practice just outside the city of Berne. Finally in 1634 he died.

It was not until after Fabricius' death that his work was collected and the most important portions gathered into a single work. The first edition, written in Latin and published by J. Beyer at Frankfurt am Main, appeared in 1646. It was reprinted many times later and translated both into French and German. The volume illustrated here is the edition of 1679; published at Geneva by Jean Anthoine Chouet and translated from Latin into French.

The work has been arranged in the form of the textbook of the day and divided into chapters or books: The first, tumors against nature, includes also inflammatory conditions and hernia; the second, surgical observation of wounds; the third, ulcers, fistulas, etc.; the fourth, fractures and dislocations; the fifth, the operations of surgery; the sixth, general surgical observations; and finally an addendum, a treatise on gangrene and sphacelus. Following the index and concluding the volume are the illustrations, printed from engraved copper plates.

Fabricius Hildanus, like his French predecessor Paré, was an indefatigable worker, a careful observer of minute clinical detail, and a student of morbid, as well as normal, anatomy. When one seeks for any one great discovery or great advance in surgery to account for the greatness of the man, it cannot be found. To be sure, he was probably the first to remove a metallic foreign body from the cornea with a magnet, and he invented the ear speculum. As an operator he was conservatively daring, not shrinking from amputations of the thigh or the opening of deep abscesses with the cautery and scalpel, but these are details, important though they may be. Rather his greatness lies in his painstaking methods and attention to detail. His friendships with his contemporaries must also be mentioned. Much of the material for his collected work came from his letters to his friends. One feels that for him his motto "Omnis tutela a Deo" could not have been better chosen.

REVIEWS OF NEW BOOKS

FEELING that there is a growing tendency to rely upon laboratory and other auxiliary reports for a diagnosis, Bailey emphasizes the fact that the "history and physical methods of examination must always remain the main channels by which a diagnosis is made." This book on the demonstrations of physical signs in clinical surgery[1] is an interesting exposition of certain physical signs encountered in the wide field of clinical surgery. Methods of palpation for various organs and afflictions are illustrated by numerous excellent photographs and drawings. One might be inclined to differ with the author's statement regarding inguinal hernia (page 87) that "an impulse is much better seen than felt."

The few short paragraphs devoted to the "Differential Diagnosis of Cerebellar and Labyrinthine Disease" seem to be somewhat out of place in a book of this scope.

While not a De Quervain, the author has supplied a volume which should be of distinct value to the student in acquiring methods of surgical physical diagnosis.

FREDERICK CHRISTOPHER.

ONE might say, and truthfully, of Rose and Carless[2] that it is one of the best single volume texts on surgery in the English language, and let it go at that. To do so, however, would be to avoid a major issue.

Surgery, methods of teaching surgery, and the surgeon are rapidly changing. Recognizing fully the contributions of past generations, antisepsis, asepsis, anæsthesia, and a fairly standardized technique, it is more important to indicate to the student the changing trend from the anatomic and pathologic concepts to the rôle of physiology, not only in surgery but in all branches of clinical medicine. The old ritual of "etiology, pathology, diagnosis, and treatment" is no longer adequate as a key to surgical lore.

This text, now in its twelfth edition, is familiar to most students of the past twenty-five years. It is orderly and easily readable, and for a single volume gives an excellent survey of clinical surgery. Individual chapters such as those on general principles, bones, joints, skull, lips, and jaw are worthy of specific mention. It readily lends itself to classroom study and assignments. Its defects are those of all single volume texts on surgery; the subject has expanded beyond the possibility of adequate discussion in one volume. Its limitations are indicated in the trend of contemporary surgical literature.

The use of such a book must necessarily be limited to that of a reference work and a key to the systematic survey of the subject. In addition, the students' efforts must be directed to wisely selected monographs in representative periodicals. The twofold purpose of acquisition of fundamental knowledge, and the habit of keeping abreast with contemporary literature will thus be accomplished.

J. R. BUCHBINDER.

THE *Practice of Urology and Syphilology*[3] is ideally academic. By this, I mean it should be an outstanding text for medical students. The subject matter is easily read and digested. The contents are most complete and modern; this completeness is not marred by cumbersome details or ultrascientific theories. The illustrations are very adequate. All the above does not detract from the original intention of the author to make his book a practical one. No one will deny its practicality to the busy doctor.

The author first discusses the anatomy and embryology of the urogenital tract. This is followed by three chapters on the diagnosis of sexual and urinary maladies. The care and use of necessary instruments are well described. Instrumentation and careful physical examination of the patient are stressed. One of the most outstanding features of the book is the author's very thorough discourse on the clinical, chemical, and bacteriological examination of urine.

Urethroscopy and cystoscopy are given high rating in urological diagnosis. There is a comprehensible explanation of functional renal diagnosis and roentgenography.

The author also describes the maladies of each urogenital organ; also their general, local and operative treatment. In bladder diseases, the use of cystoscopic fulguration of tumors is stressed. Regional and local anæsthesia in urology are briefly described. The functional disorders which occur so frequently in the urinary and sexual organs are very sanely discussed. The fascinating story of the upper urinary tract, with its abnormalities, tumors, calculi, and infections, concludes Part I of the book.

In Part II, chancroidal and luetic lesions are described. Pathology and treatment are emphasized. The best opinions on the use of modern antiluetic medication are included.

Because of the vast amount of experience of the author and his ability to write tersely but lucidly, this book should be highly valued as a teaching text.

HARRY CULVER.

THE intent of the small volume of 141 pages on bacteriological equivalents[4] is to serve as a supplement to the general dictionary. The author has

[1] DEMONSTRATIONS OF THE PHYSICAL SIGNS IN CLINICAL SURGERY. By Hamilton Bailey, F.R.C.S. (Eng.). New York: William Wood and Company, 1927.

[2] MANUAL OF SURGERY (Rose and Carless); FOR STUDENTS AND PRACTITIONERS. By Albert Carless, C.B.E., M.B., M.S. (Lond.), F.R.C.S.; and Cecil P. G. Wakeley, F.R.C.S. (Eng.), F.R.S. (Edin.). 12th ed. New York: William Wood and Company, 1927.

[3] PRACTICE OF UROLOGY AND SYPHILOLOGY; A SURGICAL TREATISE ON GENITO-URINARY DISEASES AND SYPHILIS. By Charles H. Chetwood, M.D., LL.D., F.A.C.S. New York: William Wood and Company, 1927.

[4] DICTIONARY OF BACTERIOLOGICAL EQUIVALENTS; FRENCH-ENGLISH, GERMAN-ENGLISH, ITALIAN-ENGLISH, SPANISH-ENGLISH. By William Partridge, F.I.C. London: Baillière, Tindall and Cox; Baltimore: The Williams and Wilkins Company, 1927.

selected about 2,400 French, 2,600 German, 1,200 Italian, and 1,600 Spanish words having bacteriological significance and has given the English equivalents. The words from each language are grouped separately. While no claim is made for completeness of selection yet the more important and usual words have apparently been successfully chosen and intelligently translated. Because of its convenience of size and content, the book should prove of value to those who have occasion to read or refer to the bacteriological literature of these several countries.

ALEXANDER A. DAY.

THIS cleverly assembled little book on advances in anatomy[1] aims to present some of the recent advances in anatomy as an exhibit for the enlightenment of such as might not be aware that anatomy is advancing. As a missionary tract it should do particularly well in the author's homeland where the sterile blight of traditional anatomy continues and the experimental method, as practiced in America, remains the monopoly of physiologists. This particular British skeleton is deliberately rattled by the author in the introduction when relating a conversation with a physiologist who told him his task was easy since "there are no recent advances in anatomy." One cannot imagine a physiologist on this side of the water talking so—unless, indeed, he were purblind and gouty.

Nor can one agree with the author's further contention that the recent advances in anatomy are merely typical bits of physiology that anatomists try a hand at. It so happens that the physiologist is commonly concerned with functional activities *per se* whereas your anatomist usually inclines to use physiology as a tool for the explaining of the anatomical pattern at the bottom of it all. An inspection of the table of contents or a casual turning of the pages of the present volume will convince even the casual browser that it records the work of anatomists *sensu stricto* and not of apostates to another science.

The author further confesses that this new outlook is the result of a year's sojourn at Johns Hopkins which "exercised a great influence in determining his attitude to the venerable subject of anatomy." A moderately captious critic might remark at this point that the wonder of it all must have rendered him myopic as well, for many of the topics and the viewpoint adapted reflect the local attitude there, even sometimes to the unjust suppression of depreciation of good data so unfortunate as to emanate elsewhere. Lest this stricture appear unjust, one may, by way of example, inquire why the greatest controversy in the history of American anatomy, that of the origin of endothelium, now settled at the expense of Hopkins' prestige, should be omitted from consideration in its proper place?

As a whole the topics comprise an interesting and representative selection, although they must remain as samples reflecting the personal interests of an individual. Whereas laymen will find this book too technical, and general biologists may be disappointed in the selection of topics, those interested in the medical sciences should welcome it as an interesting and significant review—and perhaps of revelation.

The several topics comprise sixteen chapters: Microdissection; tissue culture; œstrus, ovulation and menstruation; the youngest human ovum; growth centers and organizers; the morphogenesis of nerve fibers; vital staining; the origin of the cells of the blood; the cerebrospinal fluid; postural organs; the red nucleus; the extrapyramidal system; the cerebellum; the projection of the retina in the central nervous system, protopathic and epicritic sensation; and X-ray anatomy. There are numerous illustrations, brief and ill-balanced bibliographies, and an adequate index.

L. B. AREY.

THE object of the book *Tonic Hardening of the Colon*[2] is to describe an ailment which the author believes has not been generally recognized by the medical profession. He points out that Sir Charles Sherrington has shown that a muscular fiber may, as a result of nervous control, become fixed in any condition of extension or contraction and become static. This is in contrast to the ordinary contractile mobile power of muscle.

The author believes that the colon, as well as other portions of the gastro-intestinal tract, may become afflicted with more or less persistent "static fixation." This he terms "tonic hardening of the colon." Objectively, this condition results in a hard palpable colon which is tender to pressure. Subjectively, the patient is afflicted with multitudinous symptoms which run the gamut of what are usually considered functional nervous symptoms. The author lists crying spells, screaming fits, neuralgic pain, mental depression, labyrinthine vertigo, hyperacidity, lapse of memory, phobias, vasomotor symptoms, lassitude, reflex vomiting, as well as pain in the abdomen, which occurs after meals, on awakening in the morning, and coming on after midnight.

The treatment consists of giving liquid hydrarg. perchlor. and liquid ferri perchlor. as an "intestinal antiseptic," salol on occasions, lactic acid bacilli at other times, and in other instances, atropine. He advises a diet which eliminates coarse food and vegetables rich in cellulose.

In a general way the picture described corresponds to what is ordinarily called spastic colitis with marked neurotic manifestations.

The author's views are advanced with keen enthusiasm in the subject. It is not a book for Missourians.

V. C. DAVID.

[1] RECENT ADVANCES IN ANATOMY. By H. Woolard, M.D. Philadelphia: P. Blakiston's Son & Co., 1927.

[2] TONIC HARDENING OF THE COLON. By T. Stacey Wilson, M.D., B.Sc. (Edin.), F.R.C.P. (Lond.). New York and London: Oxford University Press, 1927.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

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EIGHTEENTH ANNUAL CLINICAL CONGRESS IN BOSTON

UNDER the leadership of a strong and representative committee of Boston clinicians, a program of clinics and demonstrations in the hospitals and medical schools of that great medical center is being arranged for the eighteenth annual Clinical Congress of the American College of Surgeons during the second week of October, from Monday, October 8th, to Friday, the 12th, inclusive. All departments of surgery—general surgery, gynecology, obstetrics, orthopedics, urology, and surgery of the eye, ear, nose, throat, and mouth—will be represented in this program, which will include clinics and demonstrations at the following institutions: Harvard University, Boston University, and Tufts College medical schools; and the following hospitals: Beth Israel, Boston City, Boston Dispensary, Boston Lying-In, Peter Bent Brigham, Robert Brigham, Cambridge, Carney, Children's, Deaconess, Faulkner, Free Hospital for Women, Huntington Memorial, Long Island, Massachusetts Eye and Ear Infirmary, Massachusetts General, Massachusetts Homeopathic, New England Baptist, New England Hospital for Women and Children, and St. Elizabeth's.

The morning of Monday, October 8th, will be devoted to the annual hospital conference which will be continued on Tuesday and Wednesday. Operative clinics and demonstrations in the hospitals and medical schools are scheduled for Monday afternoon and for both morning and afternoon of each of the three following days. A preliminary clinical program is to be published in an early issue of SURGERY, GYNECOLOGY AND OBSTETRICS.

As at previous sessions, a series of evening meetings is planned and the programs therefor are now being prepared by the Executive Committee of the Congress and will be published in this journal at an early date. These will include a number of highly interesting papers on various surgical subjects of present-day interest presented by eminent surgeons of the United States, Canada, and Great Britain. At the Presidential Meeting on Monday evening, to be held in Symphony Hall, the President-Elect, Dr. Franklin H. Martin, will be inaugurated. Another feature of that evening's program will be the John B. Murphy Oration in Surgery. The meetings on Tuesday, Wednesday, and Thursday evenings will be held in the grand ballroom of the Copley-Plaza Hotel. On Friday evening the annual Convocation will be held in Symphony Hall.

Since the last session of the Clinical Congress in Boston in October, 1922, a number of new hotels have been built including the Statler with 1300 guest rooms. Several of the older hotels have been rebuilt or enlarged so that there are now ample first-class hotel accommodations in Boston for all who will attend.

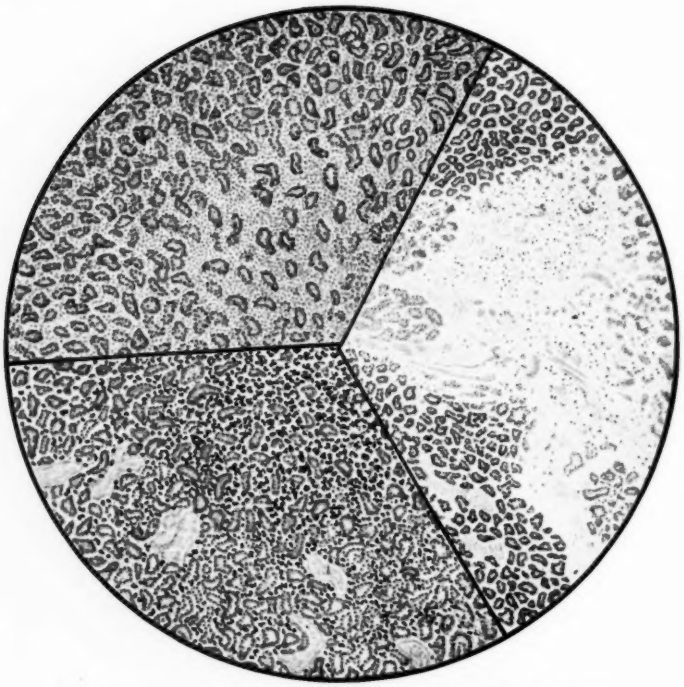

Fig. 1. Necrosis, inflammation, and hæmorrhage, the three components of the pathologicohistological picture of acute pancreatic necrosis.

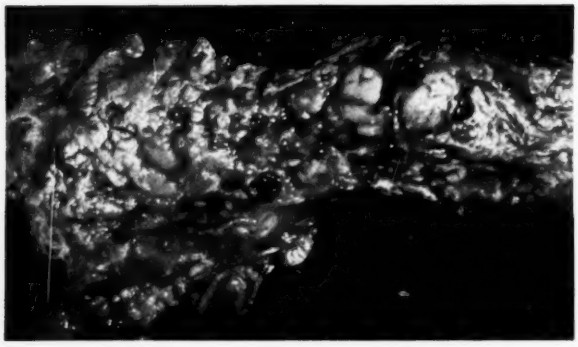

Fig. 2. Acute pancreatic necrosis, 48 hours after onset of disease.

Surgery of the Pancreas.—V. Schmieden and W. Sebening

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